THE NATVRAL HISTORY OF ANIMALS

The Natural History of Animals

BEAVERS (CASTOR FIBER) AT WORK CONSTRUCTING DAM

BEAVERS (*Castor fiber*)

The Beaver has a wide distribution in the temperate parts of Europe and North America, though its numbers are rapidly diminishing on account of the merciless way in which it has been hunted down for the sake of its pelt. This furnished the material from which top-hats and the like were originally made. Originally dwelling in a simple burrow scooped out in a river-bank, the animal has gradually evolved into a skilled architect, capable of constructing a dam across the course of a stream, the framework consisting of the trunks and branches of trees felled by the powerful incisor teeth. Upon the dam rounded dwellings or "lodges" of mud are constructed, with openings well below the water level. The broad flattened tail is a swimming organ, and is not used as a trowel as often stated.

The Natural History of Animals

The Animal Life of the World in its various Aspects and Relations

BY

J. R. AINSWORTH DAVIS, M.A.
TRINITY COLLEGE, CAMBRIDGE
PROFESSOR IN THE UNIVERSITY OF WALES, AND PROFESSOR OF ZOOLOGY AND GEOLOGY IN UNIVERSITY COLLEGE, ABERYSTWYTH

HALF-VOL. VII

LONDON
THE GRESHAM PUBLISHING COMPANY
34 SOUTHAMPTON STREET, STRAND

CONTENTS

HALF-VOL. VII

NERVOUS SYSTEM AND SENSE-ORGANS

CHAPTER LVII.—GENERAL PRINCIPLES—NERVOUS SYSTEMS OF BACKBONELESS ANIMALS (INVERTEBRATA) AND BACKBONED ANIMALS (VERTEBRATA)

CHAPTER LVIII.—SENSE-ORGANS OF BACKBONELESS ANIMALS (INVERTEBRATA) AND BACKBONED ANIMALS (VERTEBRATA)

ANIMAL INSTINCT AND INTELLIGENCE

CHAPTER LIX.—GENERAL PRINCIPLES—INSTINCT AND INTELLIGENCE IN HIGHER BACKBONELESS ANIMALS (INVERTEBRATA) AND BACKBONED ANIMALS (VERTEBRATA)

INSTINCT AND INTELLIGENCE IN HIGHER INVERTEBRATES (INVERTEBRATA)

INSTINCT AND INTELLIGENCE IN VERTEBRATES (VERTEBRATA)

ASSOCIATION OF ORGANISMS—THE WEB OF LIFE

CHAPTER LX.—ASSOCIATION OF ORGANISMS—GENERAL PRINCIPLES—ANIMALS AND PLANTS

PLANTS AND ANIMALS

CHAPTER LXIV.—ASSOCIATION OF ORGANISMS—COURTSHIP AND MATING

CHAPTER LXV.—ASSOCIATION OF ORGANISMS—MESSMATES OR COMMENSALS (COMMENSALISM)

CHAPTER LXVI.—ASSOCIATION OF ORGANISMS—PARASITES

UTILITARIAN ZOOLOGY

CHAPTER LXVII.—ANIMAL FRIENDS—ANIMALS AS A SOURCE OF FOOD—DOMESTICATED MAMMALS

WILD ANIMALS AS A SOURCE OF FOOD

DOMESTICATION OF ANIMALS

LIST OF ILLUSTRATIONS

HALF-VOL. VII

COLOURED PLATES

BLACK-AND-WHITE ILLUSTRATIONS

N.B.—Figs. 1123, 1124, 1125, 1129, 1130, and 1131 are from Alcock's *A Naturalist in Indian Seas*, by the courtesy of Mr. John Murray.

NATURAL HISTORY

NERVOUS SYSTEM AND SENSE-ORGANS

CHAPTER LVII

GENERAL PRINCIPLES—NERVOUS SYSTEMS OF INVERTEBRATES AND VERTEBRATES

GENERAL PRINCIPLES

Some of the properties of living matter or protoplasm have already been pretty fully considered, in sections which may be regarded as expansions of part of the brief sketch of Human Physiology given in vol. i, pp. 24–59. We have seen that protoplasm is a very complex and eminently unstable substance, which is continually breaking down into simpler compounds, with the result that stored or potential energy is transformed into actual or kinetic energy, without which movement and other life-manifestations would be impossible. The breaking-down process ultimately results in the formation of waste products, which being physiologically useless are cast out of the body. One such product is carbonic acid gas or carbon dioxide, and a primary object of Breathing or Respiration is to get rid of this. But Breathing also includes the taking in of free oxygen, without which the breaking down of the complex body-substance would not take place at the rate necessary for liberating the energy required. We have also seen that the gradual wasting of the body associated with the breaking-down process requires to be made good; hence the necessity for Food, which is built up into fresh protoplasm. In cases where Growth is taking

place the food taken in must obviously be larger in amount than when it is merely a question of compensating for waste. By a process of over-growth with subsequent separation from the parent-body new individuals are developed, capable of leading independent existences, and ultimately giving rise to a further generation in their turn. Another very characteristic property of protoplasm is Contractility, *i.e.* spontaneous change of shape. Hence all the various kinds of Animal Movement, without which food could not be secured, enemies escaped, or unfavourable surroundings quitted.

The present section is an expansion of the last part of the brief sketch of Human Physiology already mentioned, *i.e.* the part headed Nervous System and Sense Organs. What these are, and why they should exist, cannot be understood without reference to another fundamental property of protoplasm, which we may broadly term Sensitiveness and Spontaneity, there being, unfortunately, no briefer way of putting it. The surroundings of an animal are constantly changing; all sorts of external agents are continually acting upon it to varying extents; and life wholly depends upon successful adjustment or adaptation to this perpetually altering Environment. Alternations of day and night, succession of seasons, tidal flow and ebb, variations of food-supply, the diminution or increase in number of enemies, may be taken as examples of changes which have much to do with the preservation or extinction of old species and the evolution of new ones. That protoplasm is *sensitive* means that it is not inert to its surroundings, but reacts, in ways which tend to the preservation of life, to the influences which are constantly affecting it. If, when you are not looking, someone touches your hand with a red-hot poker, the member thus treated is drawn back without the exercise of will-power, and immediately after a painful sensation is experienced. This practically illustrates the fact that human protoplasm is sensitive to one external agent, *i.e.* heat, and the usefulness of reaction is sufficiently obvious. If animals were not sensitive to heat many of them would very quickly perish in an untimely manner. And a little consideration will make it apparent that Sensitiveness to a great variety of external agents is absolutely necessary to existence. All actions, however, are not the direct results of external agents acting for the time being. Protoplasm is *spon-*

taneous, i.e. it performs actions which find their starting-point within the body itself, as in the case of many voluntary human actions.

Any change in the surroundings which brings the sensitiveness of an organism into play is technically known as a stimulus (L. *stimulus*, an ox-goad), and stimuli may broadly be classified as mechanical, chemical, thermal, photic, and electrical. The corresponding stimulating agents are pressure, change in chemical nature of the surroundings, heat, light, and electricity, which are scientifically defined as different forms of energy, or, to use the old expression, "force". Protoplasm, like every other kind of matter, may be regarded as made up of excessively minute particles or molecules, much too small to be seen with even the most powerful microscope, which are in a state of constant vibration, throbbing, or to-and-fro movement. The pendulum affords a simple example of vibratory movement. It may further be said that every sort of stimulus is of the nature of a vibration, *e.g.* in a sound-wave transmitted through air the particles of air move in a particular way and at a rate depending upon the pitch of the sound. All the changes that take place in living matter result from modifications in the movement of its molecules, but we are profoundly ignorant of what exactly takes place when, say, a muscle-fibre contracts or an impulse passes along a nerve. The adjustment to surroundings that is necessary for the maintenance of life results from these molecular changes in the body, which take place in response to the action of pressure, heat, light, &c., these themselves being of a vibratory nature, as has already been stated. So far as an animal is "sensitive" to its surroundings it is comparable to a complex musical instrument capable of playing all sorts of tunes with all kinds of variations, in response to external influences of different kind. The reaction of an animal to its environment at any given moment depends upon how external agents are acting upon it at that moment: it is they which "call the tune". If the supposed musical instrument could also play tunes of its own accord, independently of the *direct* action of the surroundings, such tunes might be taken to represent the "spontaneous" actions of an animal.

That Sensitiveness and Spontaneity, as above defined, are essential properties of living matter, may best be realized by

studying a very simple organism, such as the Proteus Animalcule (*Amœba*), which is a particle of comparatively pure protoplasm (fig. 1006). That this creature is sensitive to mechanical stimuli is easily proved by tapping the glass slide on which one is crawling about under the microscope. The protruding lobes of the body (pseudopods) by which creeping is effected will be drawn in, and the animal will assume a spherical form (fig. 1006, A).

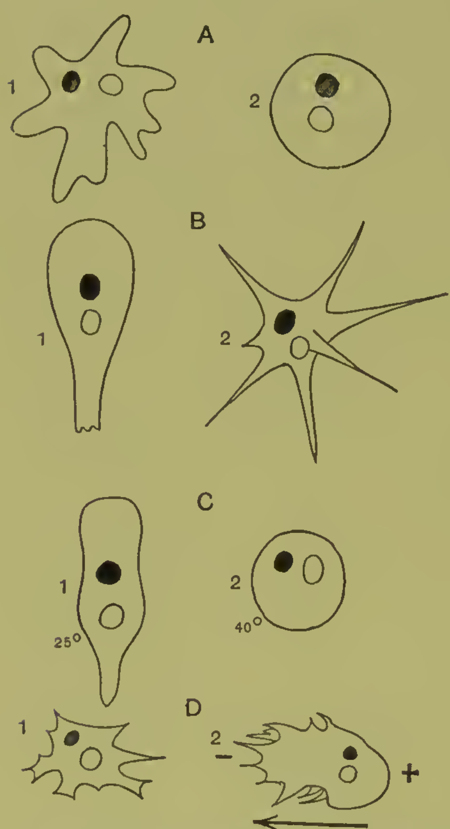


Fig. 1006. — Proteus Animalcules (*Amœba*), much enlarged, showing effect of various stimuli. 1 and 2, Appearance before and after application of stimulus. See text.

A good example of chemical stimulation is afforded by the addition of very weak caustic potash to the water in which the slug-shaped species of Amœba (*A. limax*) is moving along, the reaction consisting in this case of the protrusion of long pointed pseudopods (fig. 1006, B). The same kind of Amœba reacts in a marked way to changes of temperature (fig. 1006, C). At freezing point (0° C.) it is spherical and inert; as the temperature increases from 0° C. to 35° C. it moves about with ever-increasing activity; above this the activity gradually diminishes; and at about 40° C. the animal has assumed a spherical form, and dies in a condition of "heat-stiffening" or coagulation. This illustrates very well the fact that any particular stimulus has only a certain range of action, the range in this case being between 0° C. and 40° C., which are known as the *minimum* and *maximum* points of heat-stimulation for this particular animal. Between these two points is an *optimum* one (35° C. in this instance), at which the stimulus exerts its greatest effect by way of promoting activity. Light does not appear to affect the creeping movements of Amœba, but is said to check the taking in of food, which process goes on most actively at night. If a constant current of electricity is passed through the body of an Amœba which is protruding pseudopods in all directions it will begin to creep against the current, and all those pseudo-

pods will be drawn in which are not at the front end for the time being (fig. 1006 D).

Since a hungry Amœba creeps actively about for a long time we are probably justified in concluding that some of its movements are spontaneous, and these are probably initiated by chemical changes which take place within its body, and may be called internal stimuli.

NERVOUS SYSTEMS OF INVERTEBRATES

The Amœba, like most other animalcules, is a single cell or structural unit, which has to discharge all the functions of life, and does not exhibit the principle of division of labour to the same extent as animals belonging to the higher groups, which are collectively termed Metazoa, as contrasted with the Animalcules or Protozoa. Every member of the former group is made up of more or less numerous cells, and may therefore be styled a *cell-community*. It is clear that in such a case advantageous adjustment to the surroundings is best secured on the principle of division of labour, by which the vital activities are shared among the members of the community. Evolution on these lines has resulted in the development of Digestive Organs, Respiratory Organs, Organs of Movement, &c., the complexity of which is very great in some of the higher groups of animals. Hence the need for some means of central control, some way of correlating the diverse parts of the body, and at the same time of adjusting the body to its environment. These duties are discharged by the Nervous System, with the aid of Sense Organs, which keep it in touch with external agents. The Sensitiveness and Spontaneity of a Metazoon, in fact, are more or less centred in the Nervous System and Sense Organs, and this is true to an increasing extent as we consider animals higher and higher in the scale. At the same time it must not be forgotten that every cell in the body is endowed with *all* the primary properties of protoplasm, though cells specialize as it were in different directions, according to the nature of the organs of which they form a part.

NERVOUS SYSTEMS OF ZOOPHYTES (CŒLENTERATA). — The members of this primitive group, comprising Freshwater Polypes (*Hydra*), Hydroid Zoophytes, Jelly-Fish, Sea-Anemones, and

Corals, correspond to a fairly early stage in the evolution of the Metazoa from simple colonies of Protozoa, and furnish us with some idea of the way in which nervous systems have arisen. Reduced to its simplest terms the body of such an animal is practically a living stomach, and is made up of two layers of cells—an inner one (endoderm) and an outer one (ectoderm). We are here more especially concerned with the outer layer. It would appear that the nervous system was first evolved in the interest of adjustment to the surroundings, and it is not therefore surprising to find that it has come into existence by modification of some of the cells making up the ectoderm, since this layer immediately adjoins the outer world. The same is also true for the essential parts of all the sense-organs. These specialized nervous elements are known as *nerve-cells* or *ganglion cells*, which constitute so many centres of correlation and control. A typical cell of the kind is star-shaped and possesses a large nucleus, but it may also be round or ovoid. In Vertebrates, of which our knowledge is considerable, it is usual for a nerve-cell to be prolonged into a number of branching prolongations, and one nerve-fibre, which may be of very great length (fig. 1007). It is convenient to speak of the cell with its extensions as a *neuron*, and investigation will probably show that the neurons of Invertebrates are broadly similar to those of Vertebrates, though in many instances our knowledge is here very incomplete. It is clear that the nerve-cells need to be in communication with the environment, the parts which they control or correlate, and other similar cells with which they cooperate. This is provided for by the slender extensions of the cell-body, which constitute lines of communication. There is reason to think that the branching extensions are paths of conduction *to* the cell, while the nerve fibre is a similar path *from* the cell. It was formerly believed that the neurons in a nervous system are united together by their processes into a complicated net-work or *plexus*, but it is now known that in Vertebrates at any rate this is not so, though the slender extensions of one neuron are closely adjacent to those of others. The same thing is probably usually true for Invertebrates.

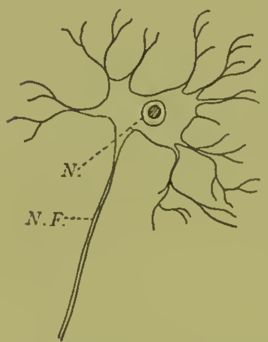
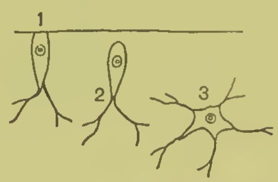


Fig. 1007. — A Typical Neuron, much enlarged. *N.*, Nucleus; *N.F.*, nerve-fibre (cut short).

Although neurons belong to the external cell-layer they do not remain at the surface of the body, but sink as it were more or less inwards to take up a more sheltered position, leaving to sense-cells the duty of reception of stimuli from external agents. In some Jelly-Fish we find cells of the external layer which are beginning to sink in to constitute neurons, while others have actually done so and acquired at the same time a more specialized shape (fig. 1008, A).

A nervous system of very primitive kind is found in a Sea-Anemone, which, leading as it does a sluggish life fixed to some firm object, does not require any very elaborate correlating mechanism. There is here a delicate continuous nerve-layer underlying the ectodermal cells that directly adjoin the exterior, and made up of innumerable neurons of which the extensions run in all directions (fig. 1008, B). Even in this case, however, there is a certain amount of centralization, for the nerve-layer is thicker in the upper side of the body where the mouth is placed, and in the tentacles which fringe this region.

A



B

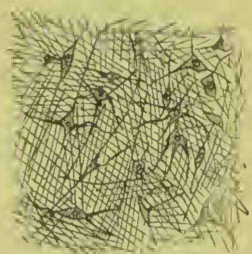


Fig. 1008.—A, Stages in the Evolution of the Neurons of a Jelly-Fish, enlarged. B, Part of the Nerve-Layer in a Sea-Anemone, showing Neurons, enlarged

The free-swimming Jelly-Fish, having more complex adjustments to effect with the environment than their fixed relatives, possess, as might be anticipated, a more centralized nervous system. It is true that there is here also a continuous nerve-layer in the deeper part of the ectoderm, but part of this is concentrated into what may be called a *central nervous system*. This may be either in the form of a double nerve-ring placed near the edge of the umbrella, or it may consist of small masses of neurons placed at regular intervals in the same region.

NERVOUS SYSTEMS OF SEGMENTED WORMS (ANNELIDA).—The members of this group are comparatively complex in structure, and possess a well-defined nervous system, that conforms to the two-sided or bilateral symmetry of the body. The primitive nerve-layer in the ectoderm is retained more or less, but it is largely superseded by the central nervous system, which consists of a nerve-ring surrounding the front end of the digestive tube, and a double nerve-cord running along near the under

side of the body (fig. 1009). In the lower Annelids this system is closely connected with the ectoderm or outer layer of the skin, but in the more specialized members of the group it has sunk within the muscular layers of the body-wall, where it is much better protected. Connected with these central organs are a large number of slender nerves, that come into intimate relation with the various organs of the body, and are made up of excessively minute nerve-fibres which are prolongations of the nerve-cells. On the upper side of the nerve-ring are two little swellings, that may be regarded as an incipient brain or chief central organ, and are technically known as ganglia. A ganglion is a thickened part of a nerve-cord, where nerve-cells are concentrated as a result of evolution along centralizing lines. The ventral cord swells into a pair of ganglia in each segment of the trunk, for which they act as controlling organs. In such a form as the Earth-Worm the ganglia are not very distinct, and nerve-cells are scattered throughout the whole of the central nervous system, but in the free-living Bristle-Worms and Leeches concentration of nerve-cells has taken place to a much greater extent, and the ganglia are clearly marked. The relations of these active forms to their surroundings are comparatively complex; hence greater concentration of nerve-cells with increased efficiency of the nervous system. The complex nature of the neurons will be gathered from fig. 1010, which represents a few of them in part of the ventral cord of an Earth-Worm.

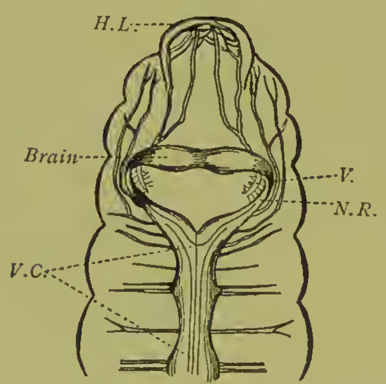


Fig. 1009.—Front Part of the Central Nervous System of an Earth-Worm, enlarged. *H.L.*, Head-lobe; *N.R.*, side of nerve-ring; *V.*, visceral or sympathetic nerves; *V.C.*, ventral cord, giving off nerves, and swollen into indistinct ganglia

The front end of a bilaterally symmetrical animal, such as a segmented worm, is more subject to the action of external agents than the rest of the body, and becomes specialized into a *head*, in which the most important part of the nervous system, *i.e.* the brain, and the chief organs of sense are located. Even in a segmented worm we are justified in considering the brain as the highest part of the nervous system, because it is the chief centre of correlation and administration. Voluntary action, consciousness or awareness of existence, sensation, and intelligence, so far as these exist in so lowly an animal, are dependent upon

it. That this is so in the common earth-worm we know from the fact that the mole stores up these unfortunate creatures as a sort of living larder, having previously bitten off the front ends of their bodies, and consequently removed such brains as they possess. This does not destroy life, but prevents the victims from crawling away. The ventral nerve-cord is subordinate to the brain, but exerts a considerable amount of independent control, each pair of ganglia dominating the ring or segment to which it belongs. To these collections of nerve-cells are due what are technically known as *reflex actions*, which are quite independent of will. We may instructively consider one common sort of reflex action which manifests itself in muscular movement. If the skin of one of the segments is stimulated mechanically, chemically, or otherwise, some amount of contraction in the muscle of the body-wall immediately follows. For the performance of this or any other reflex action three nervous elements are requisite: (1) a nerve-centre consisting of one or more, usually of several, nerve-cells, which in the latter case co-operate with one another; (2) one or more nerve-fibres constituting an *afferent* tract carrying impulses *to* the nerve-centre from sensitive ectodermal cells which have been acted upon by the mechanical, chemical, or other stimulus; and (3) one or more nerve-fibres forming an *efferent* tract carrying impulses *from* the nerve-centre to the executive structures which perform the reflex action, these being muscle-fibres in the case supposed (fig. 1011). Even in ourselves many actions are of reflex nature, *e.g.* the involuntary withdrawal of the hand from a red-hot substance as described on an earlier page (p. 2).

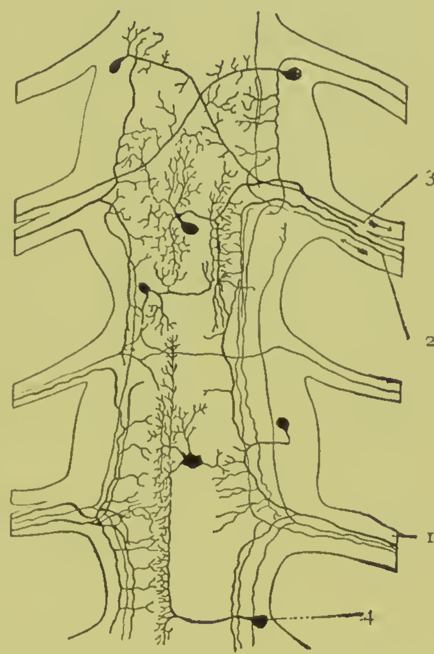


Fig. 1010.—Diagram of part of the Ventral Cord of an Earth-Worm, showing a few Neurons, enlarged. The two arrows (on the right) indicate the direction of nerve-impulses. 1, Nerve-roots; 2, afferent nerve-fibres; 3, efferent nerve-fibres; 4, a neuron, of which the branches extend through three segments

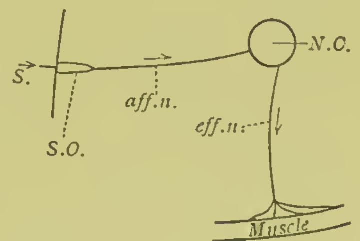


Fig. 1011.—Diagram of a Simple Reflex Action. *S.*, Stimulus; *S.O.*, sense-organ; *aff.n.*, afferent nerve; *N.C.*, nerve-centre; *eff.n.*, efferent nerve. Direction of nerve-impulses indicated by arrows.

It has already been stated that one of the duties of a nervous system is to correlate the organs of the body itself, and even in an earth-worm there is a special arrangement for controlling the digestive organs, and consisting of nerves which run from the sides of the nerve-ring to the gut, and branch out in a complex way, the branches swelling here and there into extremely minute ganglia. This arrangement is called the *visceral nervous system*, and, like the ventral cord, is subject to the control of the brain.

Before leaving segmented worms one feature in the nerve-cord is deserving of notice. It is distinctly of double nature, and in some cases its two longitudinal halves are widely separated (fig. 1012). In the evolution of this type of nervous system it is probable that each side of the body developed and was regulated by its own longitudinal nerve-cord, and this is actually the arrangement found in the curious unsegmented forms known as Nemertine Worms. Though these constitute a special group quite distinct from Annelids, they are descended from common ancestors, some of the primitive characters of which they have probably retained, one being the possession of a strong lateral nerve on either side, instead of a double ventral cord (fig. 1013). Such an arrangement is not a desirable one, for it means imperfect correlation between right and left sides of the body. The ventral cord of an Annelid has quite likely been derived from lateral cords of the kind, which have migrated downwards and come into more or less intimate relation with one another in the interests of centralization.

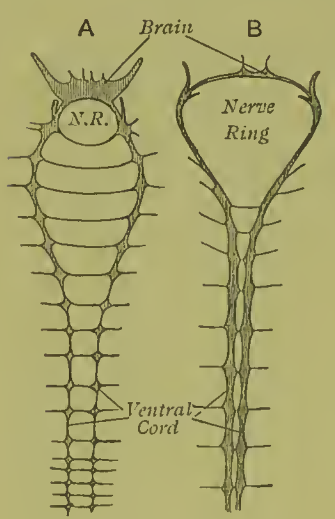


Fig. 1012.—Front Part of Central Nervous System in two Marine Annelids, enlarged. In A the two halves of the ventral cord are fairly far apart, while in B they are close together but not fused. *N.R.*, nerve-ring.

Nervous Systems of Jointed-Limbed Invertebrates (Arthropoda).—There can be little doubt that the members of this huge group have sprung from ancestors which resembled Annelids in many respects. But they have specialized in various ways, partly as the result of centralizing tendencies which have resulted in increased complexity of structure, associated with very perfect adjustment to surroundings. The body, instead of being greatly elongated and made up of a large number of rings or segments, is comparatively short, and composed of relatively few segments.

In the higher members of the group, *e.g.* lobsters and insects, the segments in front have fused into a well-developed head, followed by a thorax, to constitute which other segments have coalesced, while this is succeeded by an abdomen, where the amount of union of segments varies greatly in different cases. These three successive regions of the body differ greatly from one another as to size and shape, and may undergo further fusion. Thus, in a

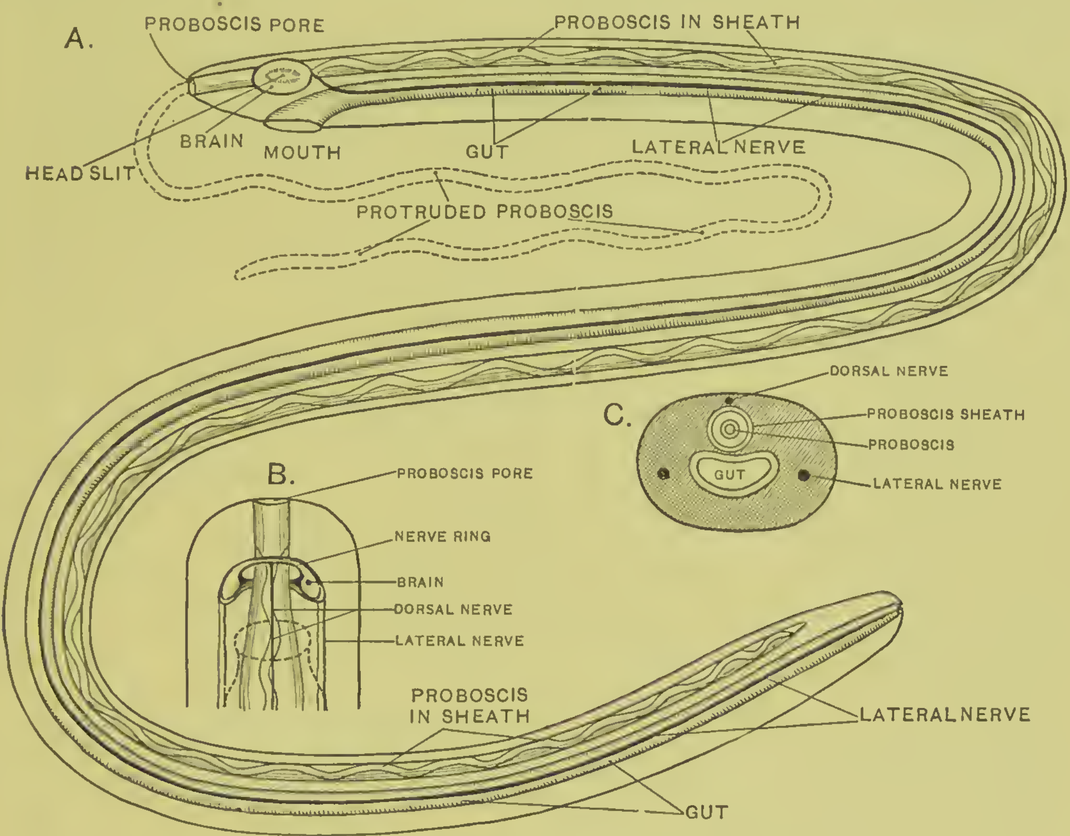


Fig. 1013.—Diagrams to illustrate Structure of a Nemertine Worm, represented as a transparent object A., Side view; B., front end, seen from above; C., cross section.

Lobster, head and thorax are welded together, and in a Spider not only is this so, but the abdominal segments have closely united into a rounded mass.

The nervous system of an Arthropod, like that of an Annelid, consists of nerve-ring and double ventral nerve-cord, but the ganglia are better developed, and in the higher members of the group they are more or less fused together into larger nerve-masses, just as the segments to which they belong are similarly united. There is, in other words, an increasing amount of centralization in the nervous system as we pass from lower to higher forms in any subdivision of the Arthropods. And this is clearly

advantageous in regard to correlation of the different parts of the body, and adaptation to the environment. It may also be noted that while in many lower Arthropods the two halves of the ventral cord are more or less separate, they are intimately united together in higher forms.

Nervous Systems of Crustaceans (*Crustacea*). — Successive stages of fusion in the nervous system may be illustrated by comparison of Apus, Crayfish, and Crab. In the first of these, which is one of the lower forms, there is a nerve-ring with clearly-marked brain, and a ventral cord of which the two halves are widely separate (fig. 1014). The brain of a typical Annelid, such as the Sea-Centipede (*Nereis*), is lodged in a head-lobe (prostomium) that forms the front of the head and overhangs the mouth, and it supplies with nerves the eyes and feelers which are borne upon this lobe (fig. 1014). The brain of Apus is placed in a corresponding position, and is in the main equivalent to that of Nereis, though probably not entirely so. A Crustacean possesses two pairs of feelers (antennules and antennæ) situated in front of the mouth, but most likely their original position was behind that aperture, and they have shifted forwards into a position more suitable for the work they have to perform, by way of exploring the surroundings. These two pairs of feelers belong to two segments of the head, each of which is provided with a corresponding pair of ganglia. In Apus those of the segment to which the antennæ belong are the first pair of the ventral cord (see figure), but the nerve for each front feeler or antennule arises from the side of the nerve-ring, and can be traced into the brain. This is intelligible if we suppose that organ to be equivalent to the brain of an Annelid, plus the ganglia supplying the antennules, which have shifted forwards along the sides of the nerve-ring. If this view be correct, a certain amount of fusion and centralization has taken place at the front end of the nervous system in Apus, as compared with an Annelid. But it is here necessary to state that

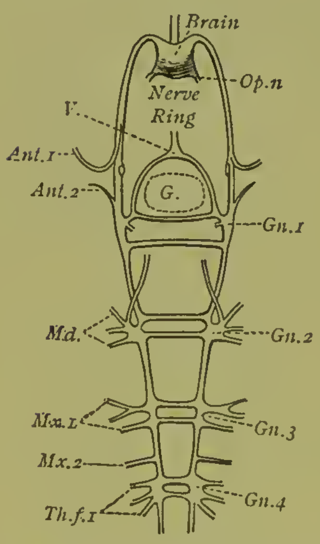


Fig. 1014.—Front Part of the Central Nervous System of Apus, enlarged

G., Place where gullet runs through nerve-ring; *Gn.1–Gn.4*, ganglia of one half of ventral cord; *Op.n*, *Ant.1*, *Ant.2*, *Md.*, *Mx.1*, *Mx.2*, *Th.f.1*, nerves to eyes, antennules, antennæ, mandibles, first and second maxillæ, and first thoracic feet; *V.*, visceral nervous system.

some authorities hold a different view as to the antennules, believing that these have always been situated in front of the mouth, and are in reality outgrowths from the head-lobe. If so they are comparable to the sensitive palps on the head of a Nereis, and the brain of Apus is strictly equivalent to the brain of an Annelid. We shall assume here the truth of the first view, as the balance of evidence is in its favour.

The body of Apus is made up of a comparatively large number of segments, while in Crayfish and Crab, as in all members of the highly-organized group (Decapoda) to which they belong, there are relatively few, *i.e.* twenty, so far as can be definitely made out. Five belong to the Head, eight to the Thorax, and seven to the Abdomen, each with a pair of ganglia and, except the last, provided with a pair of limbs. The nervous system of the Crayfish has undergone a certain amount of fusion and centralization (fig. 1015). The brain is larger and more complex than that of Apus, and it supplies not only the first but also the second feelers, the ganglia corresponding to which have shifted along the nerve-ring. Even greater fusion has taken place at the front end of the ventral cord, where there is a large ventral ganglion, which has resulted from the union of the last three pairs of head-ganglia (supplying the three pairs of jaws), and the three first pairs of thoracic ganglia (supplying the three pairs of foot-jaws). It is interesting to notice that the third thoracic ganglia are caught as it were in the act of uniting with those in front of them. The last five pairs of thoracic ganglia (supplying pincers and walking-legs) are clearly defined, although by reference to the figure it will be seen that the last two are beginning to unite, while just in front of this the doubleness of the cord is practically demonstrated by the fact that its two halves diverge, for the passage of an artery which runs vertically downwards from the heart to supply the ventral region of the body. The first five pairs of abdominal

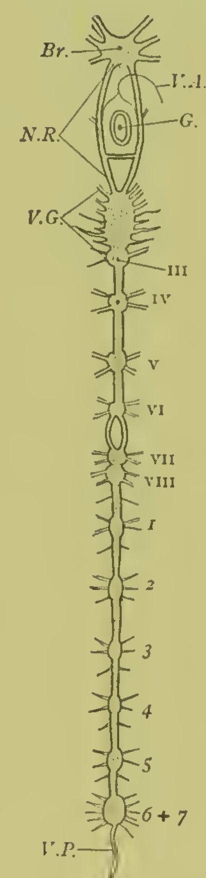


Fig. 1015.—Central Nervous System of Crayfish

G., Gullet (in cross section); *Br.*, brain; *N.R.*, side of nerve-ring; *V.G.*, ventral ganglion; III–VIII, ganglia of third to eighth thoracic segments; 1–7, ganglia of abdominal segments; *V.A.* and *V.P.*, anterior and posterior visceral nerves.

ganglia are quite distinct, and smaller than those of the thoracic region, in correspondence with the relatively small size of their segments. But the last two pairs have united into a somewhat larger nerve-mass, which supplies the last two segments of the body, that include the large tail-fin. It has been shown by experiment that the brain of the Crayfish is the dominating centre of the nervous system, while the remaining nerve-masses are centres of reflex action for the segments which they supply.

Turning now to the Crab, in which the head and thorax are relatively short and broad, and the abdomen insignificant, the brain is comparable to that of a Crayfish, but all the ganglia of the short ventral cord have fused together into a single mass, placed near the under side of the thorax, and perforated by the artery which runs down from the heart (fig. 1016).

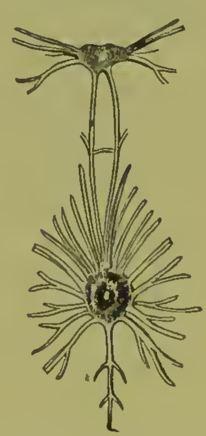


Fig. 1016. — Central Nervous System of a Crab. The brain forms the thickened front end of the nerve-ring, while the large ventral ganglion is seen behind, with numerous radiating nerves.

In all the three Crustaceans described there is a visceral nervous system, the roots of which are indicated in the figures.

Nervous Systems of Air-breathing Arthropods (*Tracheata*).—Comparison of Peripatus, Myriapods, Arachnids, and Insects will show that the same lines are followed as in Crustaceans. In the less-specialized forms, where the body is elongated and there has been but little fusion between segments, the nervous system is very like that of an Annelid. But in cases where the body is comparatively short and much fusion has taken place, the nervous system is concentrated to a corresponding degree.

We have already had occasion to see that Peripatus is the most primitive of all living air-breathing Arthropods, and has the closest affinity to Annelids. This view is fully borne out by examination of the nervous system. The upper side of the nerve-ring is swollen into a relatively large brain, and the two halves of the ventral cord are widely separate, though united by numerous transverse bands of nerve-fibres. The outer part of each cord, through its entire extent, contains numerous nerve-cells, and these are not aggregated into well-marked ganglia (fig. 1017).

Myriapods, such as ordinary Centipedes and Millipedes, are rather more specialized than Peripatus, and possess a well-marked

head, although there is no distinction between thorax and abdomen. The central nervous system consists of the usual nerve-ring and double ventral cord, and well-developed ganglia are present, between which the two halves of the cord commonly remain distinct (fig. 1018). In Centipedes there is a certain amount of fusion between the ganglia at the front end of the cord, the region from which spring the nerves of the three pairs of jaws, and also those of the poison-claws.

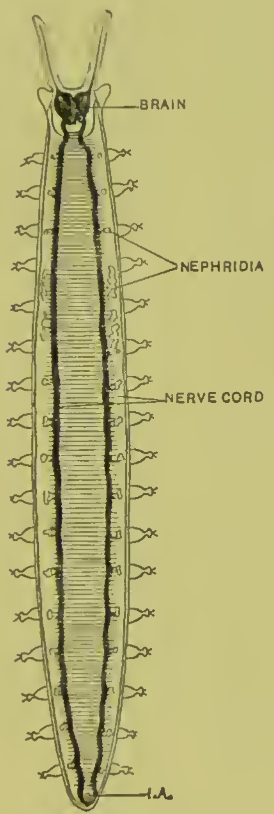


Fig. 1017.—Dissection of Peripatus from the upper side, to show Central Nervous System. I.A., Intestinal aperture.

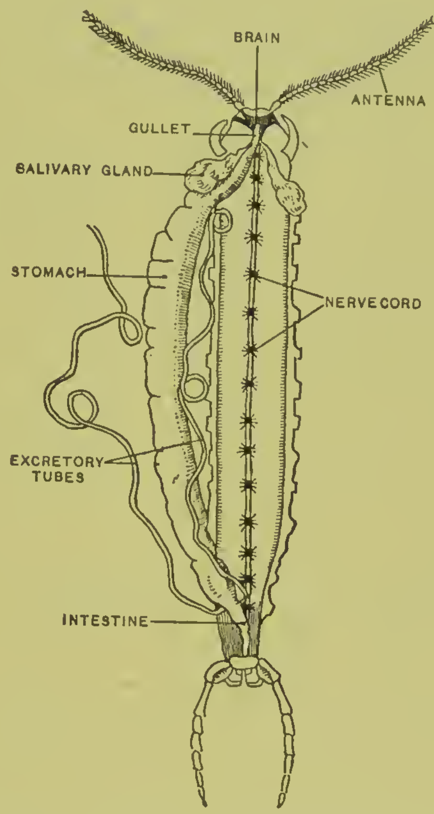


Fig. 1018.—Dissection of a Centipede (*Lithobius*) from above, enlarged

In regard to Arachnids, it will be sufficient for our present purpose to remark that the relation between the nervous system of an elongated form, such as a Scorpion, with that of a shortened form, such as a Spider or Mite, is much like that existing between a Crayfish and a Crab (p. 14). For in a Scorpion many of the pairs of ganglia of the ventral cord remain distinct, though there is a good deal of fusion between those at its front end, while in a Spider or Mite all the ganglia of the cord have consolidated into a single nerve-mass.

Among the Insects, again, we find the same principles exem-

plified. Some of the simpler forms possess a nervous system very much like that of a short Centipede, and from this condition all degrees of fusion and concentration are found, the maximum being reached where all the ganglia of the ventral cord have united into a single nerve-mass, precisely as in Crabs and Spiders. Three such stages, as exemplified by a Termite, a Water-Beetle, and a Fly, are represented in fig. 1019. In those insects which begin life as larvæ, it commonly happens that in this early stage of life the nervous system is simpler than in the adult, exhibiting less fusion and concentration. This is exemplified by comparison of a caterpillar with the butterfly or moth which it becomes, or a bee-grub with an adult bee. Cases are known, however, where the nervous system is condensed both in larva and adult, *e.g.* the House-Fly and its allies (*Muscidæ*). A curious reversal of the ordinary state of things is found in the Ant-Lion (*Myrmeleo*), for here the nervous system of the relatively short and squat larva is more concentrated than that of the elongated adult. That this should be so is probably not merely due to difference in shape, for the complex habits of the rapacious larva involve elaborate adjustments to the surroundings, which need an efficient and centralized nervous system for their proper performance (see vol. ii, p. 111). So far as we know, the life of the adult is relatively simple.

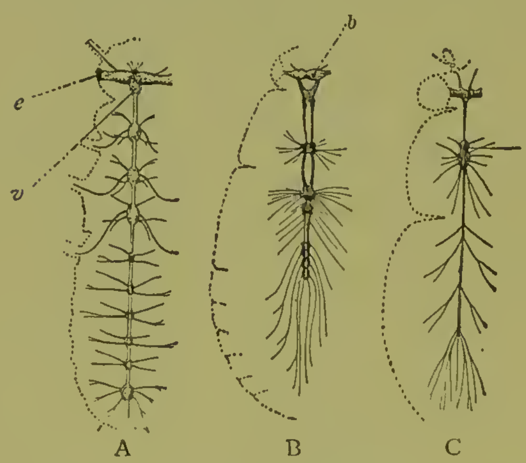


Fig. 1019.—Central Nervous Systems of a Termite (*Termes*, A), a Water-Beetle (*Dytiscus*, B), and a Blow-Fly (*Musca*, C), to illustrate stages in concentration. *b*, brain; *e*, eye; *v*, ventral ganglion.

It remains to be added that all the air-breathing Arthropods possess a visceral nervous system, which may attain considerable complexity, and takes origin from the nerve-ring.

NERVOUS SYSTEMS OF MOLLUSCS (MOLLUSCA).—The least concentrated type of nervous system is found, as might be expected, among some of the Primitive Molluscs (Amphineura). The central nervous system of a Mail-Shell (*Chiton*), for instance, consists of a nerve-ring from which four thick nerves run back (fig. 1020). Two of these are *pedal cords*, that traverse the substance of the muscular foot, while the others are *lateral cords*

placed at a higher level, and uniting with one another behind above the intestine. The nerve-cells are distributed pretty uniformly throughout both ring and cords, in the course of which are no distinct ganglia. The pharynx with its rasping organ receives branches from the nerve-ring, which *do* swell into small ganglia, and this is also the case with a pair of nerves running from the lateral cords to the under side of the stomach (see figure). In this sluggish animal digestion is the dominant function, and that is possibly why the only distinct ganglia in the nervous system are related to the digestive organs. The visceral nervous system consists in this case of (1) the nerves which run from the nerve-ring to the pharynx, (2) the lateral cords and their branches.

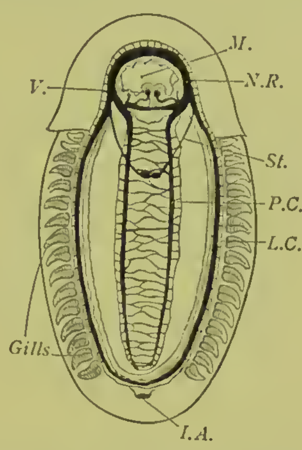


Fig. 1020.—A Mail-Shell (*Chiton*) dissected from above, to show Central Nervous System

M., Mouth; *I.A.*, intestinal aperture; *N.R.*, nerve-ring; *P.C.*, pedal cord; *L.C.*, lateral cord; *St.*, stomach nerve passing back to pair of gastric ganglia; *V.*, part of Visceral nervous system.

Passing from a simple form like the Mail-Shell to those which are more specialized, we shall find that as we ascend the scale to higher and higher types the nervous system becomes more and more centralized, in the same sort of way as in Arthropods. The nerve-cells are no longer scattered throughout the central nervous system, but are collected into definite ganglia, of which the most important are thickenings of the nerve-ring. This is very well seen in Snails and Slugs (Gastropoda), a vast number of which present a similar arrangement to that represented in fig. 1021 for the River-Snail (*Paludina*). In the middle of the figure is seen the nerve-ring, which is thickened into three distinct pairs of ganglia —(1) brain-ganglia above, (2) side-ganglia laterally (dotted in the figure), and (3) foot-ganglia below. The brain-ganglia, as shown at the top of the figure, give origin to a cord that supplies the pharynx, and swells into a pair of small ganglia from which nerves run to the pharynx. This is part of the visceral nervous system, the rest of it consisting of a nerve-loop by means of which the

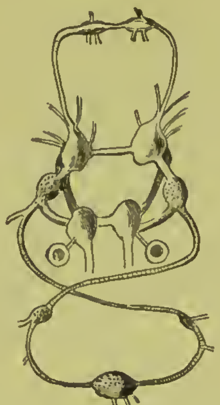


Fig. 1021.—Central Nervous System of a River-Snail (*Paludina*), enlarged. See text. The circles shaded in the centre and connected with the pedal ganglia are the so-called "ears" (*Otocysts*)

two side-ganglia are connected together, and in the course of which are three ganglia supplying many of the organs of the body. As in all Gastropods, the upper part of the body of the River-Snail has been subjected to a sort of twisting process, as the spiral shell suggests, and this has affected the nerve-loop, making it 8-shaped, as shown in the figure. This well-specialized central nervous system is associated with the presence of a clearly defined head, while just the contrary is the case in a Mail-Shell. Centralization has taken place to a still greater extent in some of the Gastropods, *e.g.* in the Pond-Snail (*Limnæus*) and Garden-Snail (*Helix aspersa*, fig. 1022), where the nerve-loop, which here has not been inflenced by the twisting of the body, is so short that its three ganglia are closely approximated to one another, and also to the foot-ganglia and side-ganglia of the nerve-ring.

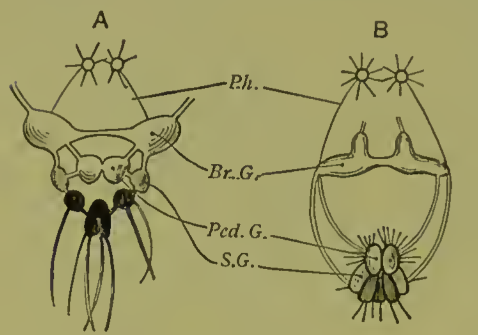


Fig. 1022.—Central Nervous Systems of Pond-Snail (*Limnæus*, A) and Garden-Snail (*Helix*, B), diagrammatic and enlarged

Br.G., Brain ganglia; *Ped.G.*, pedal ganglia; *S.G.*, side ganglia (dotted). Above are seen the small buccal ganglia connected by pharyngeal nerves (*Ph.*) with the brain ganglia, while below, the short nerve-loop with its ganglia is represented (darkly shaded).

Both in Bivalve Molluscs (Lamellibranchia) and Tusk-Shells (Scaphopoda) the nervous system follows the type described for Gastropods, but is less concentrated, and the brain-ganglia are relatively small, which may be correlated with the absence of any definite head in the former group, and its imperfect development in the latter.

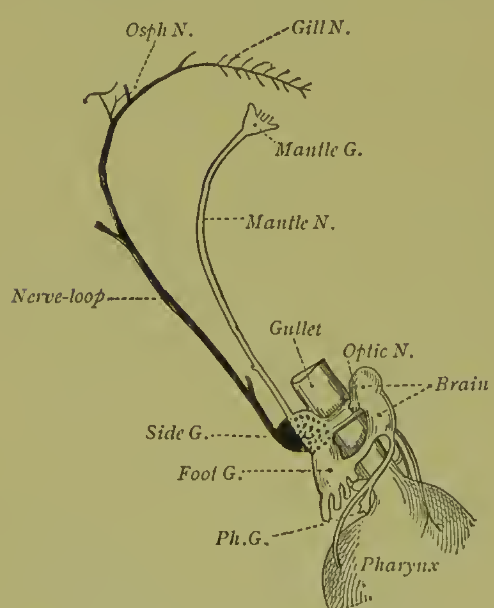


Fig. 1023.—Central Nervous System of Cuttle-Fish (*Sepia*), seen from the right side

G., Ganglia; *N.*, nerve; *Ph.G.*, pharyngeal or buccal ganglia; *Osph.N.*, osphradial nerve of water-testing organ (*Osphradium*).

Among the Head-Footed Molluscs (Cephalopoda) various degrees of concentration are found, there being the least amount of this in the Pearly Nautilus, which is a primitive and isolated type, while in the active Cuttle-Fishes, Squids, and Octopi cen-

tralization is at a maximum. The Common Cuttle-Fish (*Sepia officinalis*, fig. 1023) possesses a nerve-ring of which the ganglia are exceedingly large and closely connected. In one respect the nerve-ring is less complex than that of the Garden-Snail, for it here includes two only of the three ganglia of the nerve-loop, which is long, distinct, and, like the body, not twisted. The nerve-ring of Cephalopods is more or less enclosed in a gristly case, serving as a sort of skull.

NERVOUS SYSTEMS OF BACKBONED ANIMALS (VERTEBRATA)

The nervous system attains its maximum complexity in backboned animals, especially in the highest Mammals. The chief part of the central organs consists of a tube, which is placed near the upper side of the body, and in all but the lowest members of the group is sheltered within a skull and backbone. The front end of this nerve-tube is usually swollen into a brain, which is the chief organ of correlation and adjustment, while the rest of it is known as the spinal cord or spinal marrow. The central structures also include a visceral, or, as it is here usually called, a sympathetic nervous system, which where best developed consists of a couple of cords running longitudinally near the under side of the backbone, and swelling at intervals into sympathetic ganglia. Besides these there are outlying ganglia of similar nature in close connection with some of the internal organs, and connected with the cords just mentioned.

The body of a Vertebrate is undoubtedly made up of rings or segments, and although this is not at first sight apparent, the serial arrangement of certain structures shows it to be the case. We find, for example, that a regular succession of spinal nerves is given off from the spinal cord, one pair to each segment. From the brain arise from 10 to 12 pairs of cranial nerves, the number of which, however, does not tell us how many segments are fused to form the head. The number would be a guide if cranial nerves were precisely equivalent to spinal nerves, but this does not appear to be the case. While on the one hand some of them are complex, and equivalent to more than one pair of spinal nerves, others are only comparable to bits of such nerves, so to speak. The sympathetic system is closely

connected with the brain and spinal cord, to which it is subordinate, and its nerves branch out in the organs of digestion, circulation, &c. A few further details have already been given with regard to the nervous system of Man (see vol. i, p. 49).

It was stated at the commencement of this section that the essential elements of the nervous system, *i.e.* the neurons, are derived from the ectoderm or outer cell-layer. Considering that brain and spinal cord are far removed from the surface, while the body is traversed in all directions by nerves, it seems very difficult to believe such a statement, but the study of development shows that there is no doubt at all about the matter.

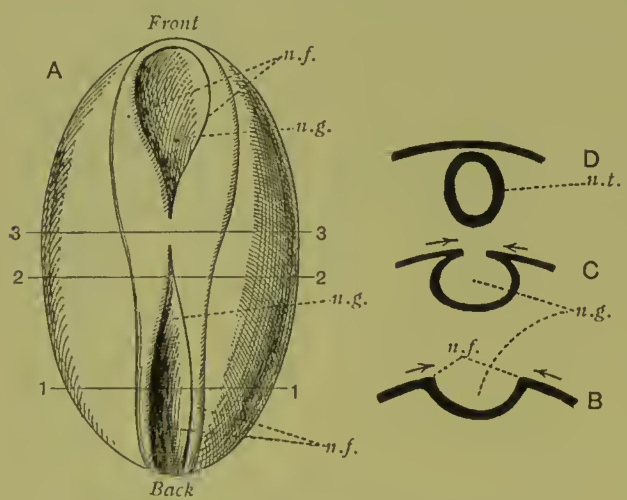


Fig. 1024.—Development of Central Nervous System in a Vertebrate Embryo, diagrammatic

A, Upper side of embryo, showing folding-up of the nerve-plate; B, C, and D, stages in folding-up of nerve-plate, as seen in cross-sections through upper part of A, taken at levels 1–1, 2–2, and 3–3; *n.g.*, nerve-groove; *n.f.*, nerve-folds; *n.t.*, nerve-tube.

At a comparatively early stage in the development of an embryo part of the ectoderm covering the upper surface thickens into a nerve-plate, which sinks below the surface, and at the same time folds up to constitute the nerve-tube. The details for the Lancelet have already been given (vol. iii, p. 345), but in that animal the nerve-plate sinks below the surface before it is completely folded into a tube, while in average cases the two processes go on simultaneously, as will be gathered from fig. 1024.

The walls of the nerve-tube thicken, and by a process of unequal growth the spinal cord and the various regions of the brain come into existence. The rest of the nervous system grows out from the nerve-tube, *e.g.* the spinal nerves grow out from the spinal cord to the parts of the body which they supply. It therefore follows that these and the other nerves, as well as the sympathetic system, are really *ingrowths* from the ectoderm or outer cell-layer, although in the adult they are far removed from the surface.

THE BRAIN OF VERTEBRATES.—At first sight the brains of Fishes,

Amphibians, Reptiles, Birds, and Mammals look so extremely unlike that comparison seems hopeless, but such an idea is soon dispelled by a study of development, which is the key to the whole matter. What takes place is broadly as follows (fig. 1025). The front end of the nerve-tube grows rapidly, and divides into three successive swellings, which we may term the Fore-, Mid-, and Hind-Brains. These three original swellings are converted into the central part or axis of the adult brain, the front part of which is called the 'Twixt-Brain, and the hind part the Medulla Oblongata or Spinal Bulb (continuous behind with the Spinal Cord), while the roof of the middle section is thickened

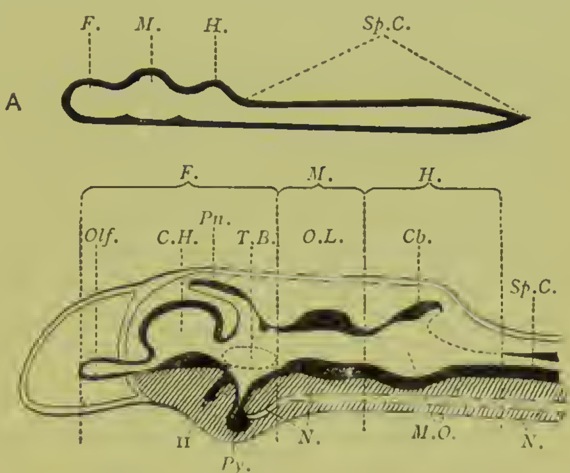


Fig. 1025.—Development of Vertebrate Brain, as seen in longitudinal section, diagrammatic

A, Brain and spinal cord at early stage; B, brain at later stage enclosed in brain-case, the floor of which is shaded with oblique lines; *F.*, *M.*, *H.*, *Sp.C.*, fore-, mid-, and hind-brains, and spinal cord; *T.B.*, 'twixt-brain; *C.H.*, cerebral hemispheres; *Olf.*, olfactory lobe projecting into nasal capsule; *Pn.* and *Py.*, pineal and pituitary bodies; *O.L.*, optic lobes; *M.O.*, medulla oblongata; *Cb.*, cerebellum; *N. N.*, notochord; II, optic nerve.

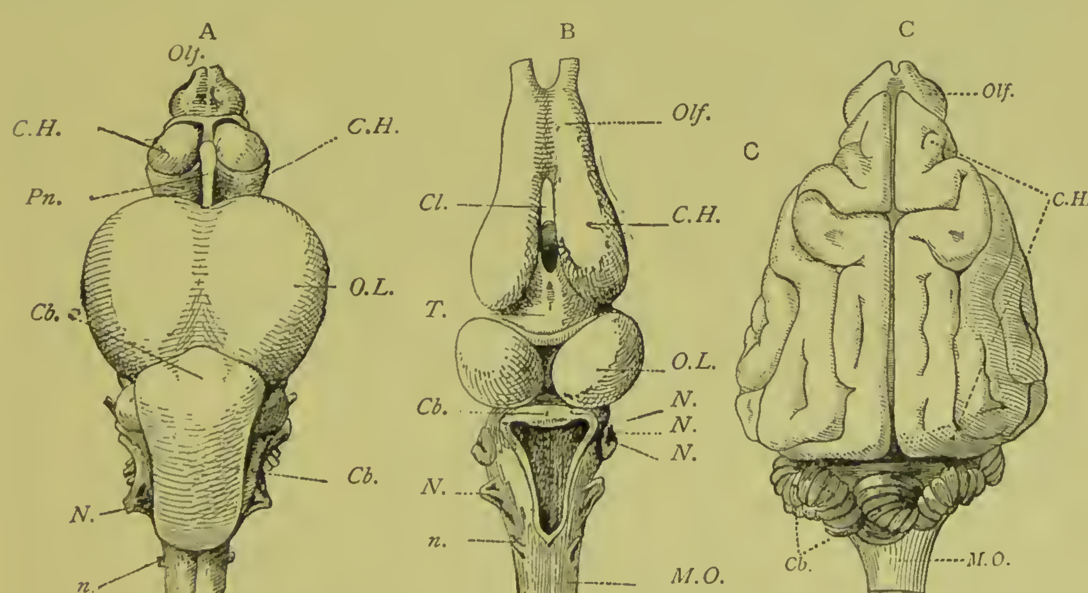


Fig. 1026.—Brains of Trout (A), Frog (B), and Dog (C), seen from above, and drawn same length

Olf., Olfactory lobes; *C.H.*, cerebral hemispheres (*Cl.* is a cleft between them in B); *T.*, 'twixt-brain; *Pn.*, pineal body; *O.L.*, optic lobes; *Cb.*, cerebellum; *M.O.*, medulla oblongata; *N.*, *N.*, *N.*, cranial nerves; *n.*, *n.*, spinal nerves.

into a pair of swellings known as Optic Lobes, each of which, in Mammals only, is divided into two smaller projections by a

transverse groove. The differences between various classes of Vertebrates mainly depend upon the relative size and structure of certain outgrowths from the axis, the position of which will be realized by reference to fig. 1026. From the 'twixt-brain two lobes grow out, which become the Cerebral Hemispheres (represented in some Fishes by a single lobe), from the front end of which spring Olfactory Lobes, related to the organs of smell. An unpaired outgrowth, the Cerebellum, arises from the upper side of the hind-brain. In Birds and Mammals the Cerebral Hemispheres and Cerebellum are of such great relative size that they largely overlap and conceal the central axis. That the brain should be made up of so many parts is a result of the division of physiological labour, these different parts sharing between them the work that has to be done. The most responsible duties are vested in the Cerebral Hemispheres, to which all the other regions are subordinate. The other regions of the brain, the spinal cord, and the sympathetic system, all have important shares in the work of the nervous system, but all are subsidiary to the cerebral hemispheres, which exercise supreme control over the body at large, and are the chief centres of correlation and adjustment. And besides this, consciousness, sensation, will, and intelligence are dependent upon them. As we ascend the scale among the Vertebrates we shall find the hemispheres getting relatively larger and more complex, as the expression of a centralizing tendency (fig. 1026). There is also a great deal of division of labour between the parts of the hemispheres themselves, and their highest duties appear to be discharged by what is known as the cerebral *cortex*, an external layer of nerve-cells. In all the higher Mammals the extent of this cortex is more or less increased by the presence of winding furrows, resulting from a process

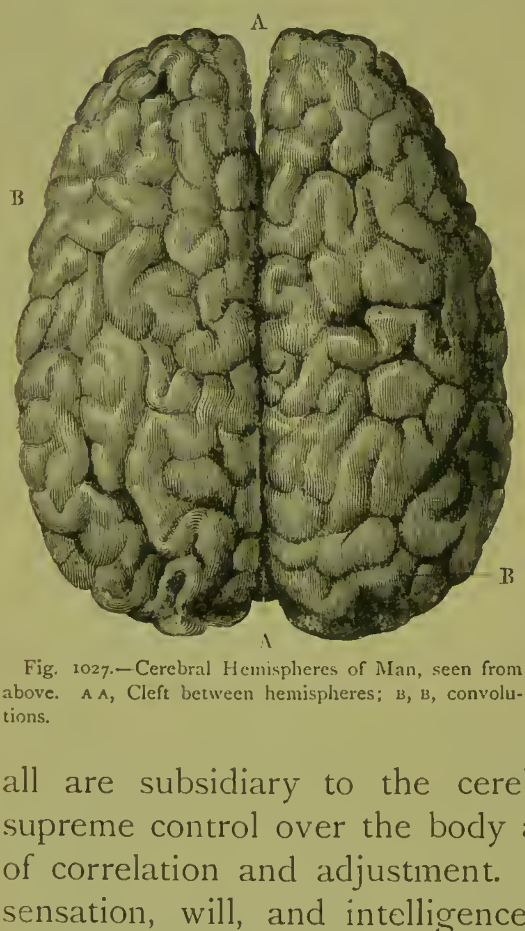


Fig. 1027.—Cerebral Hemispheres of Man, seen from above. A A, Cleft between hemispheres; B, B, convolutions.

of folding or convolution. These attain their maximum complication in the human subject, where also the hemispheres are of relatively enormous size (fig. 1027). The amount of convolution is related to the intelligence of the particular species, but hasty deductions must be avoided, since they are also proportionate to the bulk of the body. Some of the most brilliant advances in modern surgery are due to the discovery that the cerebral cortex is divided into nerve-centres, some of which are concerned with sight, hearing, and other special sensations, while others again control definite sections of the muscular system. But so far it has not been found possible to locate the higher mental functions, such, for example, as memory. The Cerebellum also possesses a very complicated cortex. As might be expected, the minute structure of the brain in a higher Mammal is most remarkably complex. Details would be out of place here, but fig. 1028, which represents one of the most specialized neurons from the cortex, will suggest the elaboration which exists, bearing in mind that the number of neurons in the brain is enormous. And it is particularly interesting to know that, as recent investigations have proved, these ultimate elements of the nervous system maintain themselves during the entire life of the animal. There are not successive crops of nerve-cells as once supposed. Were this the case, indeed, such things as memory would be almost unintelligible.

Fig. 1028.—Complex Neuron from Cortex of Human Brain, greatly enlarged

CHAPTER LVIII

SENSE-ORGANS OF INVERTEBRATES AND VERTEBRATES

Sense-organs are the intermediaries between the nervous system and the environment, and essentially consist of ectoderm cells (end-organs) capable of being influenced by external agents or stimuli. The stimulation of a sense-organ may be immediately followed by a reflex action, or it may lead to a voluntary action, and it is commonly associated, in higher animals at least, with what is technically termed a *sensation*, *i.e.* an awareness of something in the surroundings. Supposing that in ourselves a light is suddenly flashed in the eyes when it is night. The eye is first affected, then the optic nerve, and then some of the nerve-cells in the brain. It is not till these last are brought into operation that we "see a light", and by comparison with past experiences are put into possession of a piece of information about our surroundings. It must be added, that besides special sensations, such as those of hearing, sight, &c., there are others of obscurer nature, which tell us something about the state of the body itself, and are known as *organic sensations*. Such are feelings of hunger, discomfort, &c., which, though of great importance for the well-being of the body, since they often guide to actions, *e.g.* feeding, which conduce to its welfare, will not be considered here, since they are not related to special sense-organs. Nor will reference be made to the "muscular sense", by which muscular efforts are gauged.

It will be convenient to place the subject-matter of the present chapter under the time-honoured headings of Touch, Taste, Smell, Hearing, and Sight, for it is by means of sensations which can be broadly classified in this way that we derive most of our knowledge of surroundings. But many of the lower animals possess sense-organs of which we can only conjecture the use, and the stimulation of which must result in

sensations of which we can form little if any idea. And even when with reasonable certainty we can correlate sense-organs possessed by such animals with some of our own, it by no means follows that the *range* of a given sensation is the same for one of them as for ourselves. As regards hearing, for example, there is reason to think that some animals can hear sounds which are pitched much higher than any by which we are affected; nor is this very surprising when we reflect that the range of hearing is not the same in all human beings. Many persons, for example, cannot hear the high and piercing sounds made by Bats. These remarks are made as a warning against applying the results of human physiology to lower animals with too great assurance.

TOUCH

Undoubtedly the most primitive of all the senses is that of Touch, and we may broadly state that the skin is the Tactile Organ, remembering that its outer layer, commonly known as the epidermis, is no other than the ectoderm or outer cell-layer of the embryo. We must also include here the cellular lining of the mouth-cavity and, when such exist, the nasal cavities,

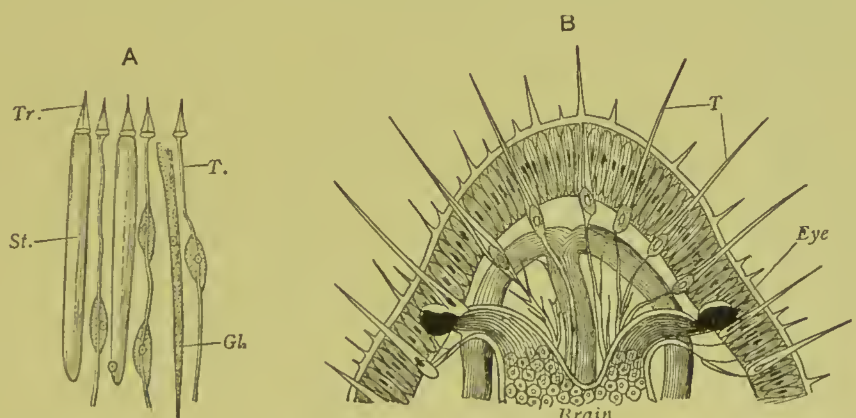


Fig. 1029.—Tactile Organs. A, Cells from the ectoderm of a Sea-Anemone (*Actinia*); *T.*, a touch-cell, with outer end produced into a stiff process; *St.*, stinging cell, with sensitive trigger-hair (*Tr.*); *Gl.*, glandular cell. B, Head of a Freshwater Annelid (*Bohemilla comata*), seen from above, and showing epidermis in optical section, enlarged; *T.*, tactile processes of some of the epidermic cells, which are continuous internally with nerve-fibres.

since these have been developed as in-pushings of the ectoderm. The external agents of stimuli which by their action upon the skin evoke sensations of touch are of two sorts. There are, in the first place, mechanical agents, such as contact or pressure, and, in the second place, heat-rays. The sensations which result are respectively known as *haptic* and *thermal*.

Single epidermal cells or groups of such cells are specialized for the reception of stimuli leading to sensations of touch, but in such forms as Cœlenterates and Annelids many scattered cells of the kind probably minister to other senses besides that of touch. And it must be remembered that even the special sense-cells of hearing and sight are derived from the skin, which is in fact the primitive sense-organ. Cells which are regarded as tactile, from some of the lowest animals, are represented in fig. 1029.

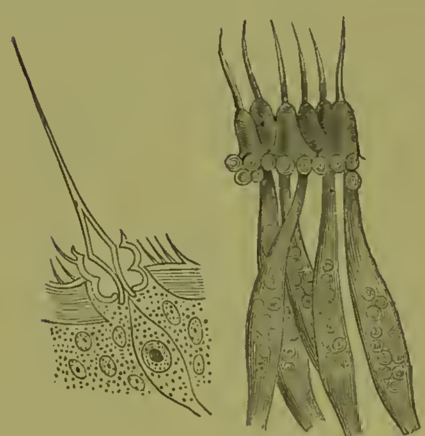


Fig. 1030. — Tactile Organs of Insects, greatly enlarged. On the right is a group of such structures, and on the left a single one, in section.

The firm external covering with which the bodies of Arthropods are clothed is naturally a hindrance to the reception of stimuli by the underlying epidermis. The difficulty is got over by the existence of little pores in the hard investment. Under each pore is an enlarged sense-cell, placed at the base of a stiff tactile bristle, with which external bodies come into contact (fig. 1030).

In aquatic Vertebrates the sense-cells of the skin are in direct contact with the surrounding medium, although they are not infrequently protected by being lodged in pits, grooves, or canals which open at intervals to the exterior. But in terrestrial Vertebrates there are special end-organs of touch which have sunk below the epidermis, though they remain sufficiently near to the surface to be stimulated when the body comes into contact with surrounding objects. Such are the groups of touch-corpuscles which are to be found in the skin of the Frog, and around the edge of the Duck's bill (fig. 1031). The latter animal feeds upon small worms, &c., which live in the mud that is strained through its bill, and such special arrangements are clearly necessary to aid in the discrimination between what is edible and what is not. Another example is afforded by the

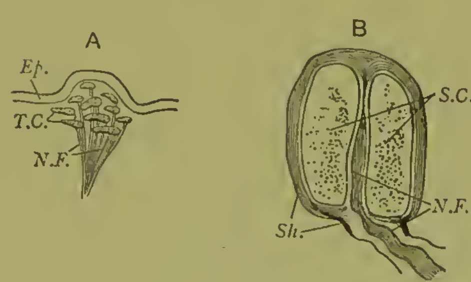


Fig. 1031.—Organs of Touch

A, Small piece of the skin of a Frog, in vertical section, enlarged; *Ep.*, epidermis; *T.C.*, touch-corpuscles; *N.F.*, nerve-fibres. B, Touch-corpuscle from the bill of a Duck, much enlarged; *S.C.*, sense-cells; *N.F.*, nerve-fibre; *Sh.*, fibrous sheath.

numerous touch-corpuscles which underlie the little ridges seen on the tips of our fingers and thumbs (fig. 1032). In Reptiles, Birds, and Mammals there are also curious structures known as Pacinian bodies (fig. 1033), in which the ending of a nerve is surrounded by a series of layers arranged almost like the coats of an onion. There is reason to think that these are very sensitive to slight pressures. They abound, for instance, in the wing-membranes of Bats, and it is well known that these creatures can easily steer their way in the dark through a veritable maze of obstacles, such as that afforded by a series of strings running in various directions. Pacinian bodies are also found connected with tendons, ligaments, and various internal organs. The use of these is probably to apprise the central nervous system of variations in pressure and tension which take place as between the different parts of the body itself.

Fig. 1032. — Touch-Corpuscle from Finger Tip of Man, in section, greatly enlarged

We are still very much in the dark as to how far there do or do not exist special end-organs which are affected by variations in temperature. It is known that definite spots in the human skin are sensitive to such variations, but there do not appear to be any special sense-organs in these spots. Some of the sensory nerve-fibres terminate in the skin by dividing into a number of little branches which do not become continuous with modified epidermal cells, and it has been suggested that these "free nerve endings" are related to the temperature sense.

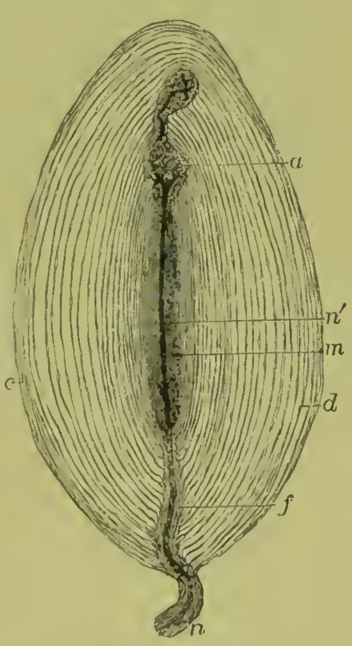


Fig. 1033.—A Pacinian Corpuscle in Longitudinal Section, enlarged. A nerve-fibre (*n n'*), surrounded by a sheath (*f*), enters the base of the corpuscle, loses its sheath, traverses a central core (*m*), and ends in an irregular expansion (*a*). The corpuscle is mostly made up of numerous concentric fibrous layers (*c*, *d*).

While the entire external surface of the body is sensitive to contact, pressure, and changes in temperature, this is in many cases insufficient to enable the requisite adjustments to the environment to be brought about. And we accordingly find that in many animals organs of active touch have been evolved, which explore the

surroundings, and help to detect the presence of food, or to give warning of danger. Such are the tentacles of Jelly-Fish and Sea-Anemones, the slender outgrowths on the head of a Sea-Centipede, the two pairs of antennæ on the head of a Cray-fish, the single pair on the head of an Insect, and the tentacles on the heads of Snails and Slugs. The "whiskers" of a Cat or Rabbit belong to the same class of structures. They are stiff

Fig. 1034.—A Deep-Sea Fish (*Eretmophorus*) with its Pelvic Fins drawn out into long Tactile Organs

hairs, at the base of each of which a touch-corpuscle is to be found. Such organs of active touch may either from the first have done duty as sensory organs, or may have originally been evolved in the interests of some other function. The former is probably true for the feelers of a Sea-Centipede or Insect, but the large feelers of a Crayfish (and very likely the small ones too) were probably jaws at an earlier stage, having later on been shifted in front of the mouth, and modified in shape and structure to do duty as sense-organs. There can be no doubt that the paired fins of Fishes were originally evolved in

relation to swimming, but it sometimes happens that they have been transformed into tactile organs, as in the deep-sea form (*Eretmophorus*) represented in fig. 1034. Snakes employ their tongues as tactile organs, as also do Woodpeckers and Ant-eaters. This, however, is probably only an extension of the original duties, for the primary use of the tongue seems to be that of a tactile organ in relation to the mouth-cavity.

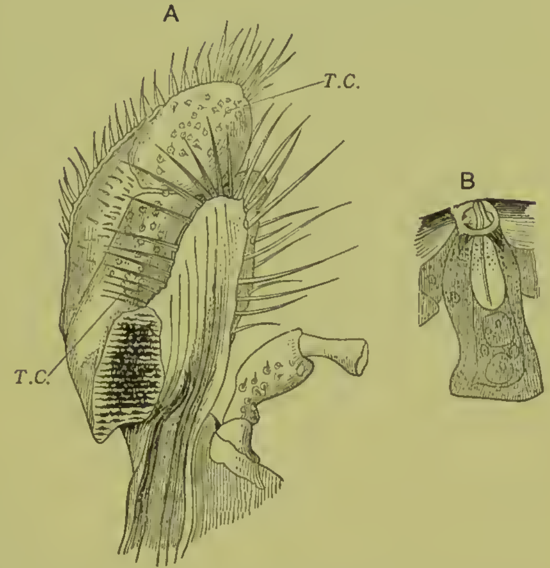


Fig. 1035.—Taste-Organs of a Wasp. A, Under side of left maxilla, enlarged, showing group of taste-cups (*T.C.*). B, A single taste-cup, greatly enlarged.

TASTE

Sensations of Taste are primarily important because they assist in the selection of suitable food. The stimulus is a chemical one, and consists of substances in solution. We know but little about the gustatory organs of lower forms, but as these show a preference for certain kinds of food it is probably correct to assume that such organs are present. In the Earth-Worm, for example, groups of modified epidermal cells in the neighbourhood of the mouth are very likely related to taste.

Certain regions of the mouth-parts of some Insects are studded with minute pits, beneath each of which is a sense-cell, drawn out externally into a short bristle, and continuous with a nerve-fibre internally. They are present, for example, in Bees and Wasps, and are almost certainly of a gustatory nature (fig. 1035).


Fig. 1036.—Taste-Bud from the Tongue of a Rabbit, in longitudinal section, greatly enlarged. The bud contains slender taste-cells, the external ends of which project into a little pit continuous with the mouth-cavity.

Cuttle-Fishes and many Snails possess a sense-organ on the floor of the pharynx, below the front end of the rasping-ribbon. It probably has to do with taste.

In Lung-Fishes, Amphibians, Reptiles, Birds, and Mammals the organs of taste consist of groups of sense-cells in the lining of the mouth-cavity, and since this cavity is developed as an

in-pushing from the exterior the cells in question are of ectodermic nature. The largest amount of specialization takes place in Mammals, where the "taste-buds", as the group of cells are called, are associated with small projections or papillæ of the surface of the tongue (fig. 1036).

SMELL

Many of the lower animals can undoubtedly smell as well as taste, though to definitely associate this sense with special cells or groups of cells is not at present possible. Our knowledge is more complete in the case of Arthropods, Molluscs, and Vertebrates, where experiments lead to results of more de-

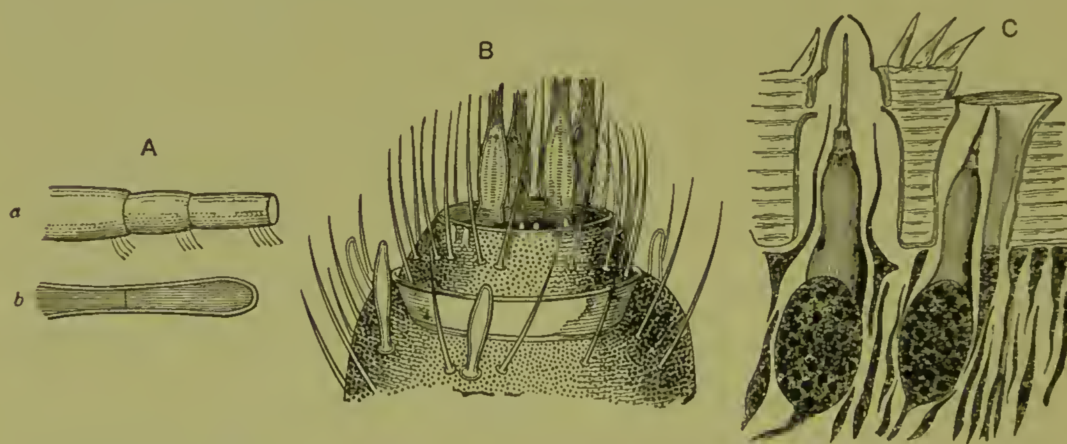


Fig. 1037.—Olfactory Organs. A, A small part of the outer branch of antennule of a Crayfish is shown at *a*, with groups of olfactory setæ on its under side, enlarged; *b*, an olfactory seta, further enlarged. B, Tip of feeler of a Millipede, greatly enlarged, showing olfactory cylinders among the ordinary tactile bristles. C, Two olfactory cones from feeler of a Wasp, in section, greatly enlarged.

finite kind. In all cases the stimulus is of a gaseous nature, and in aquatic animals the gases that are smelt are dissolved in the surrounding water. The sense of smell is obviously of great importance as regards adjustment to the environment. By its means food is in many cases detected, while it often enables animals to recognize friends or foes, even when these are at a considerable distance. This is, of course, due to the nature of the stimulus. Since Smell, Hearing, Sight, and the Temperature Sense are able to give information about objects which are more or less far away, they may be grouped together as Distance-Senses (telæsthetic senses), and are in marked contrast to Touch (so far as haptic sensations are concerned), which only conveys knowledge regarding things that actually come into contact with the skin.

There is naturally a tendency for olfactory organs to be developed at the front end of the body, where they can be most usefully employed, and they are commonly to be found on the feelers of Arthropods. In the Crayfish, for example, the small first feelers (antennules) bear groups of flattened bristles which undoubtedly have to do with smell, and similar structures are present on the antennæ of Millipedes and Insects (fig. 1037).

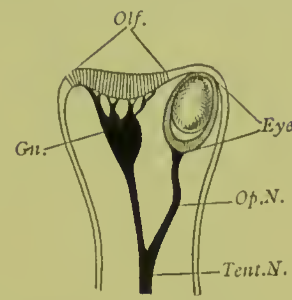


Fig. 1038.—Tip of Optic Tentacle of Garden-Snail, in diagrammatic longitudinal section, enlarged. The tentacular nerve (*Tent. N.*) gives off an optic nerve (*Op.N.*) to the eye, and then expands into a ganglion (*Gn.*) which sends fibres to an olfactory patch (*Olf.*) of cells on the tip of the tentacle.

Land-Snails and Slugs, among the Molluscs, are known to be endowed with a keen sense of smell. In the common Garden-Snail (*Helix aspersa*) some of the epidermic cells at the tips of the long eye-bearing tentacles are believed to minister to this function (fig. 1038), though experiments have been made which appear to show that olfactory cells are elsewhere present.

Among aquatic Molluscs what is known as a water-testing organ (osphradium) is usually present in the neighbourhood of the breathing organs (fig. 1039). This is generally considered to be of olfactory nature.

In Vertebrates the sense-cells related to smell form part of the lining of the cavities of the nose, and since these are developed as pits in the external surface, such cells must neccssarily be of ectodermic character. When the sense of

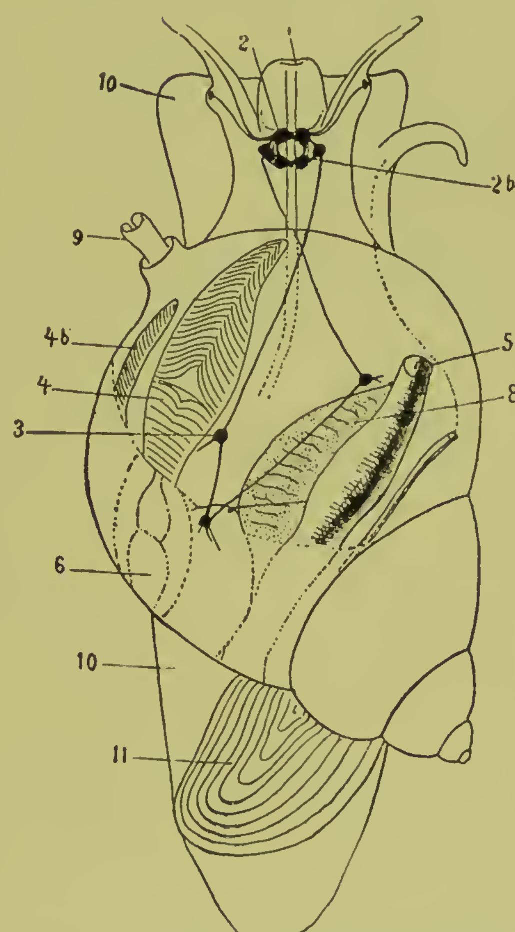


Fig. 1039.—Diagram of a Comb-gilled Snail, seen from above. The roof of mantle-cavity and overlying shell supposed transparent

1, Mouth; 2, brain ganglion; 2*b*, nerve-cord connecting side ganglion (above) with foot ganglion (below); 3, one of the three ganglia on the twisted nerve-loop; 4, gill; 4*b*, osphradium; 5, opening of intestine; 6, heart in pericardium; 8, a gland (purple-gland in Purpura); 9, siphon; 10, 10, foot; 11, operculum.

smell is keen the nasal cavities are large and complex, and folds project into them which increase the surface over which olfactory cells are distributed. These cells are frequently of the shape represented in fig. 1040, from which it will be seen that from the outer end a number of slender processes project into the nasal cavity. In some Fishes, such as the ordinary bony forms, the originally single nostril of each half of the nose is divided into two apertures, which respectively serve for the entry and exit of water, that appears to flow continuously through the nasal cavity. There can be no doubt that many fishes possess a very keen sense of smell, and the experiments of Bateson have proved that some of them (*e.g.* Dog-Fish, Conger-Eel, and Sole) are mainly guided by this in their search for food. This being so, the nocturnal habits of many species is readily intelligible, and the sense of smell must also be very useful in water of such depth that the light is dim.

Fig. 1040.—Two Olfactory Cells from an Amphibian (*Proteus*), greatly enlarged

In Vertebrates which live on land the courses taken by the food which is swallowed and the air that is breathed are more or less distinct. Each nasal cavity, in fact, opens at the back into the digestive tube, and the natural way of breathing is "through the nose". This is clearly to the advantage of the sense of smell, for the air which passes over the olfactory cells is constantly being renewed, and the incoming current is continually bringing with it gaseous matter capable of being smelt. An inward flow is greatly promoted by the act of "sniffing", as we know from our own experience.

BALANCE AND HEARING

There are certain sensory structures among the Invertebrates which though often classified as Auditory Organs have probably nothing to do with hearing in the ordinary sense, but are concerned with advantageous adjustment of the body as regards its position in space. This is of the greatest importance in reference to the maintenance of balance and the direction of movement. They are stimulated by vibrations in the surrounding medium, water or air as the case may be, and there can be little doubt that they have furnished the material from which undoubted

organs of hearing have been evolved. Indeed the auditory organs still retain, in ourselves for instance, the old function side by side with the new.

Balancing Organs of Jelly-Fish (Hydrozoa).—Jelly-Fish are often provided with balancing organs placed at regular intervals round the edge of the umbrella. In the simplest case these are little pits lined by specialized sense-cells, from each of which a bristle projects. Within the pit one or more calcareous particles (otoliths) are found, and these also have been derived from the ectoderm. In many species the mouths of these pits close up, converting them into little sacs (otocysts) which lie close to the surface. Other kinds, again, possess short balancing-tentacles (tentaculocysts), evolved no doubt from some of the ordinary sort (fig. 1041). In such instances the otoliths are derived from the entoderm cells which make up the inner part of the tentacle. Though these different organs may be constructed in various ways they are affected by the same sort of stimulus. Their sensory cells are jolted by movements in the surrounding water and by the swimming movements of the animals themselves, and the otoliths appear to intensify the action, as it were. The sense-cells are closely connected with the nervous system, and this again with muscle-fibres. We have present, in fact, the necessary machinery for muscular reflex actions (see p. 9), under which may be included the checking or stopping of swimming movements actually in progress.

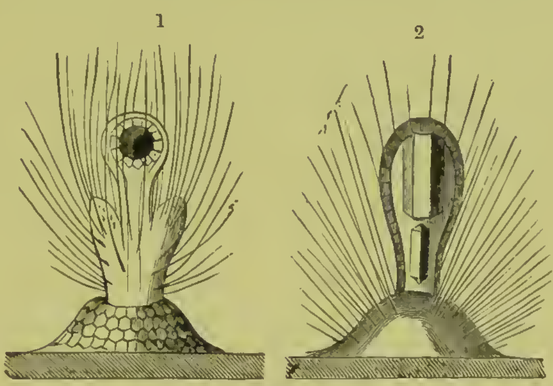


Fig. 1041.—Tentaculocysts of Jelly-Fish, enlarged

1, Of *Solmaris coronantha*; 2, of *Polyxenia cyanostylis*.

One of the most obvious uses of the sense-organs described appears to be that of enabling their possessors to keep well below the surface of the water during rough weather, for creatures of such flabby and delicate structure are quite unfitted to withstand the buffets of the waves. Supposing that on a stormy day a jelly-fish is swimming obliquely upwards. When it comes sufficiently near the surface for the balancing organs to be stimulated with a certain degree of vigour by the swing

of the water, reflex modification of the swimming movements will take place, and the upward course will be altered into a downward one.

Balancing Organs in Segmented Worms (Annelida).—Members of this group commonly react very quickly to jolting or agitation of the surrounding medium, and this may lead to movements promoting escape from danger. Earth-Worms, for example, when partly protruding from their burrows, will often draw back with extreme rapidity on the approach of a heavy footstep. The skin is no doubt the sense-organ in this case, but we are ignorant as to details. A few Annelids, however, have a pair of otocysts in the front part of the body, as, *e.g.*, the Common Lob-Worm (*Arenicola piscatorum*), where they are closely connected with the brain (fig. 1042). They have undoubtedly been evolved from pits in the ectoderm like the similar sacs found in some of the jelly-fish, and three stages in this evolution are permanently retained in three kinds of Lob-Worm. In one of these (*A. Claparedii*) there is simply a pair of depressions on the head, in another (*A. piscatorum*) otocysts which are still in communication with the exterior, and in a third (*A. Grubii*) closed otocysts. The otoliths of the second species are minute sand grains taken in from the exterior, while those of the third are calcareous particles secreted by the ectoderm.

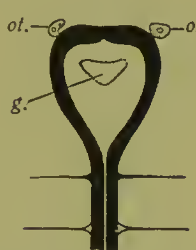


Fig. 1042.—Front Part of Central Nervous System of Lob-Worm (*Arenicola piscatorum*), enlarged. *g.*, Gullet (in cross section) traversing nerve-ring; *ot.*, otocysts in close connection with the brain (canals to exterior not shown).

Balancing Organs in Molluscs (Mollusca).—Most Molluscs possess a pair of otocysts, developed as pits in the ectoderm, which become closed and travel inwards to the neighbourhood of the foot. They are attached to the foot-ganglia, although their nerve-supply is derived from the brain (see fig. 1021, p. 17). It occasionally happens in Bivalves that the communication with the exterior is retained. The lining of these organs partly consists of sense-cells provided with stiff processes, and one or more calcareous otoliths are present.

The otocysts of Cuttle-Fishes and their allies are lodged in the gristly case which surrounds the thickened nerve-ring, pretty much as in backboned animals the corresponding organs are sheltered in gristly or bony capsules that form part of the wall

of the brain-case. And it is definitely known that in Molluscs of this kind maintenance of equilibrium and adjustment of the swimming movements are seriously interfered with if the otocysts are injured, which leaves little doubt as to the use of these organs.

The otocysts of some of the free-swimming Sea-Snails (Heteropods) are particularly large and well-developed (fig. 1043), and are undoubtedly related to balance and steering. The majority of Snails and Slugs, however, are adapted to a creeping mode of life, the organ of locomotion being the muscular flat-soled foot, which is also concerned with maintaining the balance of the body. Since the otocysts are presumably related to both these uses, it is not surprising to find them placed close to the upper surface of the foot, by the slightest movement of which they must therefore be affected, and H. J. Fleure has described an interesting arrangement in the Limpet and Sea-Ear which probably conduces to this. In the two forms mentioned each otocyst is connected with the foot by a fibrous band, and there is a similar bond between the two otocysts (fig. 1044). These organs are thus kept "in touch" with the foot and with one another, and, being also moored by their nerves to the foot-ganglia, are kept steady, which seems desirable when their functions are considered.

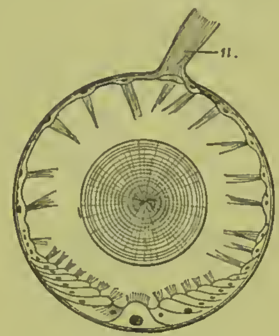


Fig. 1043.—Otocyst of a Heteropod (*Pterotrachea*), in section, enlarged. The large otolith is seen in the centre of the vesicle, which is lined below by sensory cells, provided with bunches of short, stiff projections; the rest of the vesicle is lined by cells bearing long cilia; *n.*, nerve.

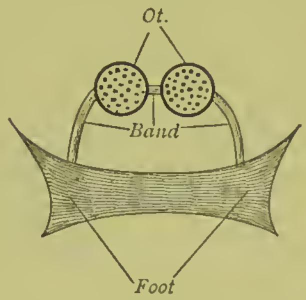


Fig. 1044. — Diagrammatic Cross Section through Otocysts (*Ot.*) and Foot of a Limpet, enlarged

Organs of Balance and Hearing in Crustaceans (Crustacea). — Such higher forms as Lobsters, Prawns, Shrimps, and Crabs are provided with otocysts lodged in the bases of the small feelers or antennules. These organs arise, as in cases already described, as pits in the ectoderm, and they usually, though not always, remain open through life. In a Lobster, for example, they are lined by a thin horny membrane continuous with the hard covering of the body, and studded with delicate bristles, at the bases of which are sense-cells (fig. 1045). The otoliths are sand grains which have been taken in from the exterior.

That the otocysts are concerned with equilibrium and adjustment of movement has been definitely proved by experiments upon the Prawn (*Palæmon*). When this creature moults it sheds not only the defensive armour of the body but also the lining of the otocysts, getting rid at the same time of the sand grains which serve as otoliths. Under ordinary circumstances these would be replaced by a fresh supply of the same material, but the specimens experimented upon were only provided with iron filings, some of which in due course were introduced into the otocysts. It was then found possible by means of a magnet to move the particles in various ways, and as a result of this the Prawns could be induced to assume all sorts of positions, under the impression, so to speak, that they were falling over in this or that direction, which they would have been if the shifting of the otoliths had been produced by ordinary causes.

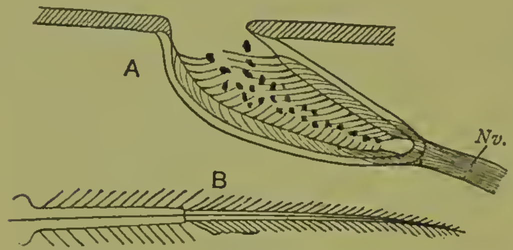


Fig. 1045.—Otocyst of Lobster (A) in longitudinal section, enlarged and diagrammatic; sensory bristles are seen projecting into its cavity, which contains numerous otoliths; *Nv.*, nerve. B, A sensory bristle, further enlarged

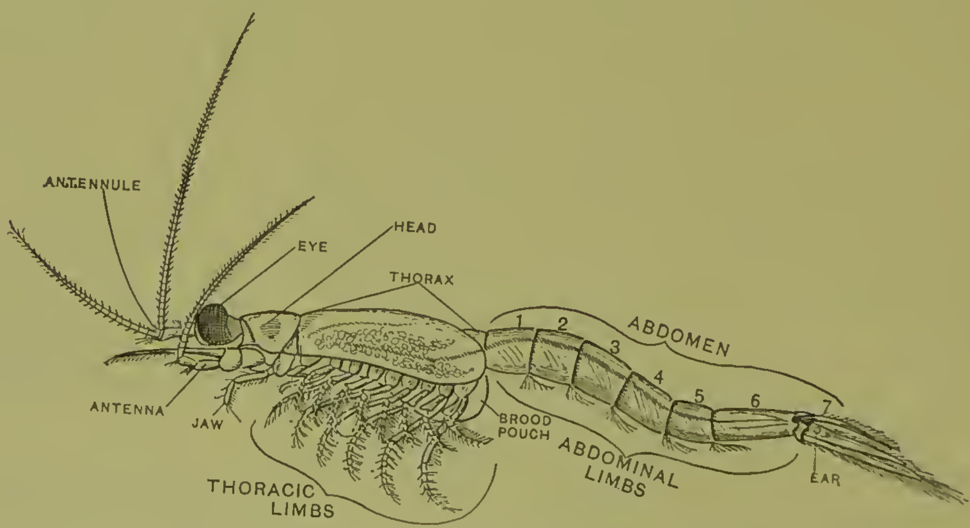


Fig. 1046.—Opossum Shrimp (*Mysis*), enlarged. One of the otocysts (EAR) is seen in the tail

In one Crustacean, the Opossum Shrimp (*Mysis*), the otocysts, in this case closed, are lodged in the flaps of the tail-fin, but why they should have this position is not known (fig. 1046).

It is generally assumed that animals which are endowed with a voice or its equivalent also possess powers of hearing, at least if the voice is used for the benefit of one another. Since some

of the higher Crustaceans are able to emit sounds, it is quite possible that their otocysts are beginning to acquire a new use, *i.e.* that of serving as auditory organs. The Rock-Lobster (*Palinurus*), for example, makes a creaking noise by moving the basal joints of the large feelers, which then rub against their sockets. An unpleasant sound of similar nature can be produced by twisting a glass stopper in the neck of its bottle. A more specialized case is that of the Musical Strand-Crab (*Ocypoda macrocera*), which has been described by Alcock (in *A Naturalist in Indian Seas*). In this animal the inner side of the large nippers is provided with a ridge or scraper placed near the base of the limb, and a rasp-like ridge or key-board on the fixed joint of the claw. By drawing the scraper over the key-board a sort of chirping sound is produced, not unlike the one with which our native grasshoppers have made us familiar. The same zoologist speaks of the Squeaker Crab (*Psopheticus stridulans*) of the Andaman Sea as making a dismal noise by rubbing a spine which projects from the base of its nippers against a rough knob near the eye-socket.

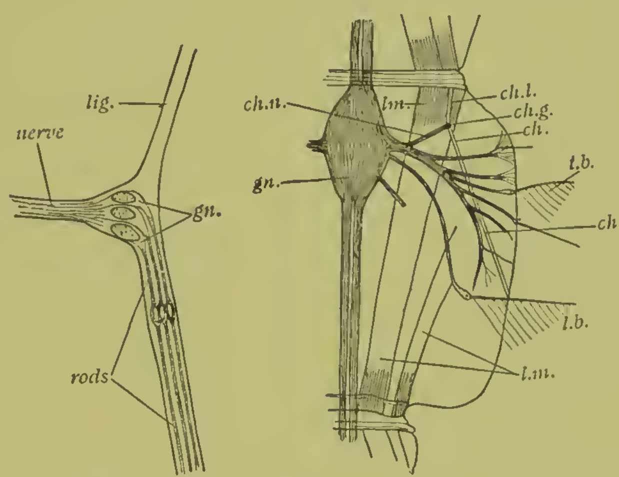


Fig. 1047.—Chordotonal Organs. On the right is shown part of an abdominal segment of the larva of a Gnat (*Corethra plumicornis*), seen as a transparent object, enlarged. In the centre is the nerve-cord (darkly shaded) with the ganglion (*gn.*) of the segment; *l.m.*, longitudinal muscles; *ch.n.*, *ch.g.*, *ch.l.*, and *ch.*, chordotonal nerve, ganglion, ligament, and organ; *t.b.*, branched tactile bristles. On the left is seen part of the chordotonal organ with its rods, ganglion (*gn.*), nerve, and ligament (*lig.*) still further enlarged.

Organs of Balance and Hearing in Insects (Insecta).—A variety of organs situated in different parts of the body are probably connected with balance or hearing, or both. Among those which are most likely concerned with equilibrium and movement are certain peculiar structures (chordotonal organs) that are especially characteristic of aquatic larvæ, though not limited to these. Gnat larvæ, for example, possess such organs, one of which is represented in fig. 1047. It consists essentially of a group of rod-shaped cells contained in a tube that opens to the exterior.

Many insects make sounds which are doubtless heard by

their fellows, a well-known instance being afforded by Grasshoppers and Crickets. A Grasshopper possesses a chirping arrangement something like that of the Musical Strand-Crab (p. 37). The wing-cover is provided with a sharp edge or scraper which is rubbed along a key-board placed on the inner edge of the thigh of the hind-leg (fig. 1048). The chirping sounds audible to our own ears are produced by the male insect, but the females of some species are also provided with these "stridulating" organs, which no doubt make sounds that can be heard and appreciated by the opposite sex. These sound-producing insects also possess what we may feel justified in calling "ears". On either side of the first ring of the abdomen there is a membrane comparable to a drum-head (fig. 1048) stretched over an air-space, and closely connected with sensory arrangements somewhat like those already described for a gnat-larva. The ears of Green Grasshoppers and Crickets are situated in the shins of the fore-legs, just below the knee.

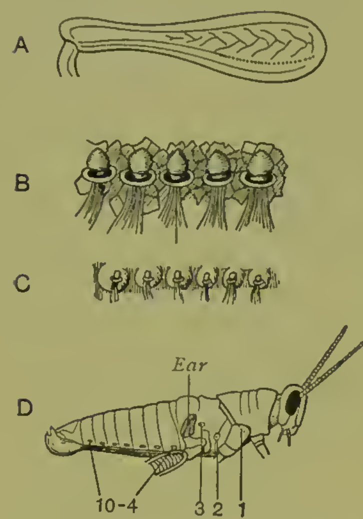


Fig. 1048.—Stridulating Organs and Ears of Grasshoppers. A, Hind-thigh of a male Grasshopper (*Stenobothrus*), showing beaded key-board (dotted line on right), enlarged; B, five beads of same, further enlarged; C, six of the much smaller beads of key-board of a female (same scale as B); D, side view of a Grasshopper (*Acridium*), to show ear; wings and legs cut short; 1–3, thoracic stigmata; 4–10, abdominal stigmata.

Organs of Balance and Hearing in Backboned Animals (Vertebrata).—The tadpole larvæ of Sea-Squirts possess remarkable sense-organs formed by specialization of part of the wall of the brain, and projecting into its cavity. One of these is of the nature of an otocyst, and is probably a balancing organ (fig. 1049).

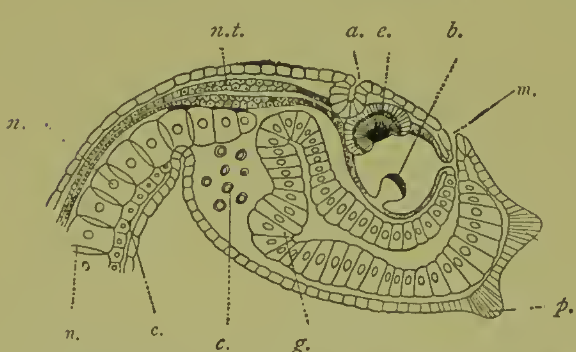


Fig. 1049.—Body of an Ascidian Tadpole, in longitudinal section, enlarged. The tail is cut short; the dorsal nerve-tube (*n.t.*) swells into a brain, into which project a balancing organ (*b.*) and an eye (*e.*); *a.*, atrial cavity; *c.*, groups of embryonic cells; *g.*, gut; *m.*, mouth; *n.*, notochord; *p.*, adhesive papillæ.

From Fishes onwards we find undoubted ears, similar, broadly speaking, to the essential parts of our own organs of hearing, and there can be no doubt that these also have to do with equilibrium and movement. If we trace the development of the

ear we shall find that it begins as a pit in the skin, and by closure of the mouth of this a vesicle is produced, which if it underwent no further modification would be called an otocyst. As it is, however, a very complex shape is assumed, the final result being known as the membranous labyrinth, or internal ear (fig. 1050). This sometimes, as in a Skate or Dog-Fish, remains in communication with the exterior throughout life. It is significant that in Fishes the auditory pit arises in close connection with the "lateral line", which is a groove or tube containing groups of sense-cells belonging to the skin. And this suggests that the ear is no more than a bit of this line which has sunk beneath the surface and become specialized as regards structure and function. It is extremely probable that the lateral line of Fishes and Amphibian larvæ has to do with maintenance of balance and direction of movements, and if so, the fact that the ear has to do with these functions is quite intelligible. We know so little about the division of physiological labour between the different parts of the complex labyrinth that a discussion of details would be out of place here. But experiments have shown that the semicircular canals have some connection with movement and equilibrium, and it is interesting to note that they lie in three planes which are mutually at right angles. It is also certain that the labyrinth is the sense-organ of hearing proper. In land-vertebrates there are more or less perfect arrangements for conducting air-waves from the exterior to the deeply-seated and well-protected internal ear. This has already been sufficiently illustrated by the brief account of the auditory organs of Man given elsewhere (see vol. i, p. 56).

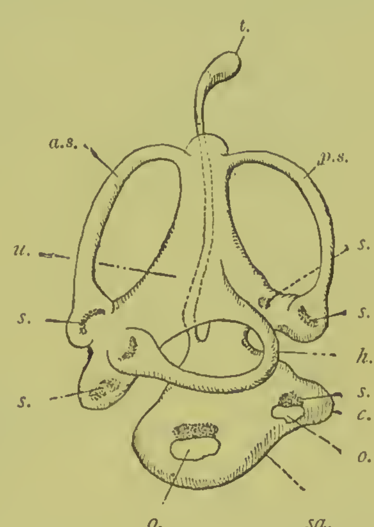


Fig. 1050.—Diagram of the Left Membranous Labyrinth of a Lower Vertebrate, seen from the outer side. *t.*, A tube representing the outer part of the original ingrowth; *a.s.*, *p.s.*, and *h.*, anterior vertical, posterior vertical, and horizontal semicircular canals; *u*, utricle; *sa.*, saccule; *c.*, cochlea; *o.*, *o.*, otoliths; *s.*, *s.*, *s.*, *s.*, *s.* (and other dotted patches), groups of sense-cells.

SIGHT

Skin-Seeing.—The simplest kind of sight is literally that of "seeing without eyes", and it amounts to no more than the power of distinguishing between light and darkness, or detecting

sudden variations in the amount of illumination. But even this limited sort of vision may be of the greatest importance to its possessor, since it often gives valuable information about the surroundings. In such skin-seeing (*dermatoptic vision*) it is usual to find colouring-matter or pigment in or below the epidermis, which localizes the action of light-rays upon sensitive cells in this layer. This is the case, for instance, in Earth-Worms, the safety of which must often depend upon their avoidance of light. A further and more interesting illustration is afforded by many of the bivalve Molluscs which live in sand or mud, and which feed and breathe by means of two tubes, the siphons, which project from the hinder end of the body (vol. ii, p. 249). Such animals are often found hidden in their burrows with only the extreme tips of the siphons projecting. But even though thus concealed they would more frequently fall victims than they do to octopi and fishes, or, in the case of those which live between tide-marks, to strand-haunting birds, were they not provided with some means of detecting the proximity of such enemies. Warning is often given by the siphons themselves, which are commonly pigmented and sensitive to changes in light-intensity. And experiments on specimens kept in aquaria have shown that the fully-extended siphons are rapidly drawn in if a shadow is suddenly cast upon them, an event that would happen under natural conditions on the approach of a voracious fish or too inquisitive bird.

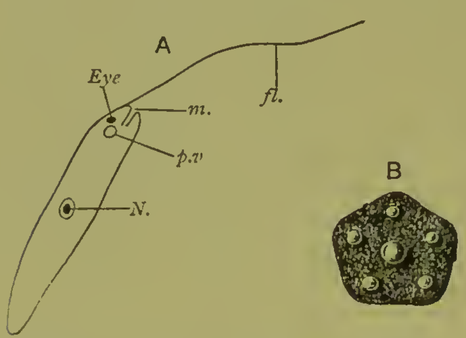


Fig. 1051.—A, *Euglena viridis*, enlarged; *fl.*, flagellum; *m.*, mouth; *N.*, nucleus; *p.v.*, pulsating vacuole. B, Eye-spot, greatly enlarged, showing six rounded lenses resting on a mass of pigment.

EYES.—Localization and improvement of the powers of sight have led to the evolution of definite visual organs or eyes, though many of the lower Invertebrates have more or less retained the old faculty of diffuse skin-seeing. The simplest organs of the kind are known as *eye-spots*, and their presence is marked by dense pigment. These are possessed even by some Animalcules, *e.g.* by a little green creature (*Euglena viridis*) which often swarms in stagnant water (fig. 1051). The eye-spot in this case is marked by the presence of a tiny patch of red colouring-matter on which rest several little lenses that serve to concentrate the light.

In some of the Jelly-Fish the margin of the umbrella bears

a number of compound sense-organs (rhopalia) derived from tentacles, and having to do with balance and adjustment of movements, sight, and possibly smell. Their visual part consists of a group of pigmented ectoderm cells, upon which a lens may rest (fig. 1052).

Examination of a Common Star-Fish (*Uraster rubens*) will

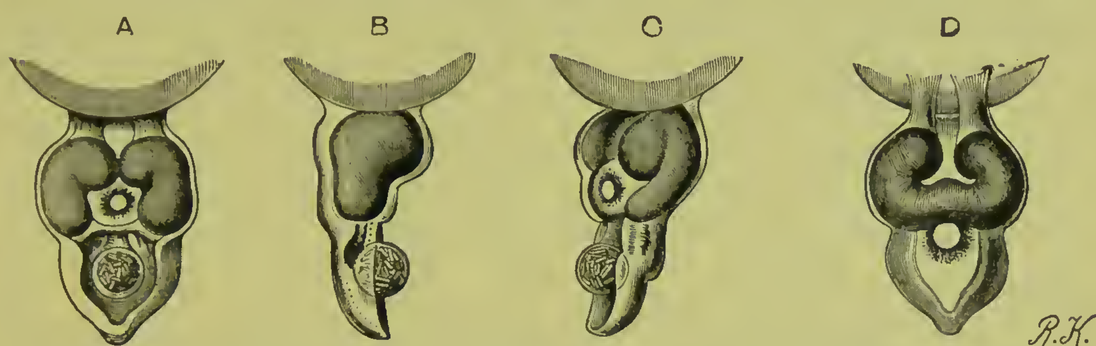


Fig. 1052.—Rhopalia of *Pericolpa quadrigata*, seen from various points of view, enlarged. The otocyst, containing numerous otoliths, is seen in the lower part of A, B, and C; the rounded pigmented eye, with clear, central, refracting portion, is indicated in A, C, and D.

reveal the presence of a bright-red spot at the tip of each arm, borne upon an unpaired tube-foot. This is undoubtedly an eye, and microscopic examination shows that it is made up of a multitude of little cups, each of which is lined with elongated cells, some of which are sensory, while others contain pigment (fig. 1053). Sea-Urchins possess a circlet of somewhat similar eyes placed near the upper pole of the body. In some of these animals each of the minute cups may be provided with refracting structures, which presumably concentrate the light.

Fig. 1053.—An Eye-Cup of a Star-Fish, greatly enlarged, in section. The retina is supplied with numerous nerve-fibres (*n.f.*).

Jelly-Fish, Star-Fish, and Sea-Urchins are radially symmetrical animals, and their eyes are correspondingly disposed. But in "Worms", Arthropods, Molluscs, and Vertebrates, where the body is bilaterally symmetrical, and there is a more or less well-developed head, the eyes are usually situated upon this, as being the most useful position. But eyes may be present elsewhere, especially in some of the Planarian Worms, and certain Bivalve Molluscs.

The visual organs so far described may be called Direction-Eyes, as they can do no more than detect the direction from which the light-rays which influence them are coming. Eyes of

the sort are present in many Worms and Molluscs, and some of them are less complex than those of a Jelly-Fish or Star-Fish. Nothing, for example, could be much simpler than the eye-spots on the head of the common freshwater worm Naïs. Each of these is simply an enlarged epidermal cell, along one side of which are several much smaller cells containing pigment (fig. 1054). We may take as examples of greater complication the eyes of a Leech, a Limpet, and an Arrow-Worm, the nature of which is sufficiently indicated in fig. 1055. They essentially consist of a group of visual or retinal cells, associated with pigment and refracting structures. Those of the Leech are particularly interesting, because they closely resemble in structure certain organs of touch which are present in the skin of the same animal, differing from these, however, in being larger, surrounded with pigment, and limited to the front end of the body. It is, in fact, a case of tactile organs which are acquiring a new function. The simple eye-cups, of which one is to be found at the base of each tentacle in a Limpet, are interesting for quite a different reason. For they are almost certainly to be regarded as degenerate structures, which have been greatly simplified as a result of adaptation to the mode of life characteristic of their possessor. The activity of a Limpet is practically limited to feeding excursions in the vicinity

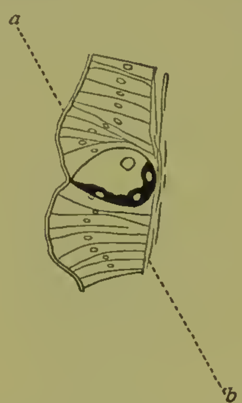


Fig. 1054.—Section through an Eye-Spot of a Freshwater Annelid (*Naïs*), with adjacent epidermic cells, enlarged. *a b*, optic axis

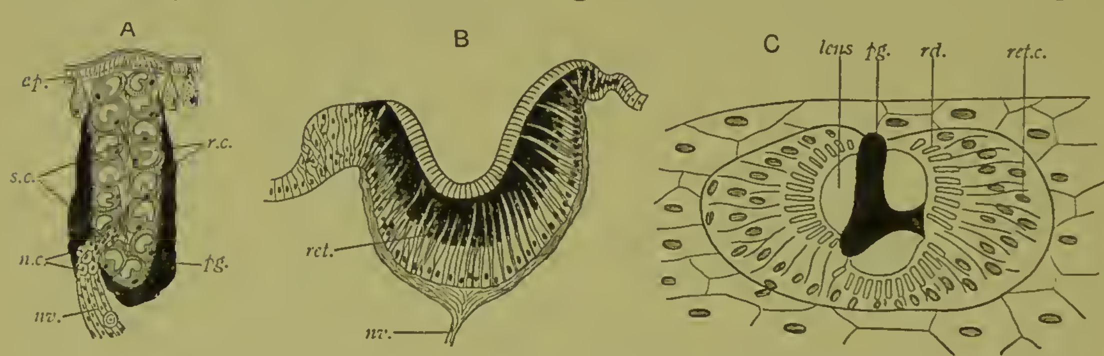


Fig. 1055.—Direction-Eyes of a Leech (*Hirudo*, A), a Limpet (*Patella*, B), and an Arrow-Worm (*Sagitta*, C), in section, and enlarged to various scales

In A the elongated eye is placed below a transparent patch of the epidermis (*cp.*); it is enclosed in a pigmented sheath (*pg.*), and consists of an external layer of large refracting cells (*r.c.*), surrounding a core of slender sense-cells (*s.c.*), which are continuous with nerve-cells (*n.c.*), and these again with nerve-fibres (*nv.*). B is an open cup, lined by a thickened retina (*ret.*) with clear refracting part externally, and dark pigment between its cells; *nv.*, nerve. In C there are three lenses imbedded in pigment (*pg.*), external to which are retinal cells (*ret.c.*), that contain refracting rodlets (*rd.*) in their inner ends.

of its home, and the eyes are under the shadow of the large conical shell. Under such circumstances complex visual organs are unnecessary.

PICTURE-EYES.—The development of refracting structures in direction-eyes has led to the possibility of further specialization in vision, and has resulted in what we may call Picture-Eyes, capable of giving more or less definite information about the form and colour of external objects. Two kinds of these may be distinguished, *i.e.* Compound Eyes and Camera Eyes.

Fig. 1056.—Head of Male Honey-Bee (*Apis mellifica*) and Beginning of Thorax with First Pair of Legs, enlarged. The antennæ are seen in front, and three small simple eyes near their bases, but the most conspicuous structures are the enormous compound eyes, with their minute hexagonal facets.

Compound Eyes are characteristic of a great many Arthropods, such as Lobsters and Crabs, where they are placed at the end of stalks, and Insects, where they are in the form of two large projections on the head (fig. 1056). Examination with a lens shows that such an eye is covered by a transparent patch of the hard covering of the body, which is divided into a multitude of minute square or polygonal areas, commonly known as facets. These may be exceedingly numerous, as will be seen from the following calculations made by Leeuwenhoek more than a century ago:—house-fly, 4000; gadfly, 7000; goat-moth, 11,000; death's-head moth, 12,000; swallow-tail butterfly, 17,000; dragon-fly, 20,000; a small beetle (Mordella), 25,000. It was originally believed that these elaborate structures were aggregates of simple eyes, acting independently; and they were therefore called "compound" eyes, a rather misleading term. Sections through such eyes (fig. 1057) have demonstrated that each facet is the outer end or base of a very slender visual pyramid (ommatidium), the external part of which consists of various refracting structures, while internally is a group of sensitive visual cells connected with nerve-fibres. Adjacent pyramids are optically separated from one another by means of pigment. Comparison of various compound eyes shows that there are

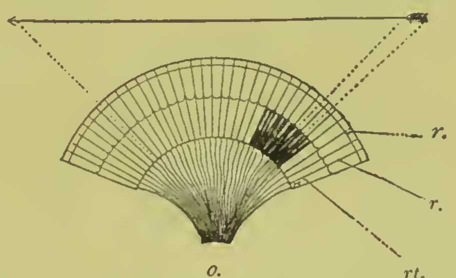


Fig. 1057.—Diagram of a Compound Eye, in section, enlarged, to illustrate theory of "mosaic vision". Numerous radiating visual pyramids are indicated, each consisting of external refracting structures (*r.*, *r.*) and internal groups of retinal cells (*rt.*). On the right side part of the pigment of several pyramids is inserted. The course of light-rays from an external object is indicated for three pyramids; *o.*, optic nerve.

great differences in detail, and much has yet to be learnt regarding the exact structure and use of the numerous parts which are present. The most plausible explanation which has yet been given of the mode of action of this sort of eye is that of "mosaic vision". According to this a visual pyramid is only stimulated by light-rays which exactly correspond in direction with its long axis, and numerous pyramids co-operate so as to enable the shape and colour of surrounding objects to be perceived (fig. 1057).

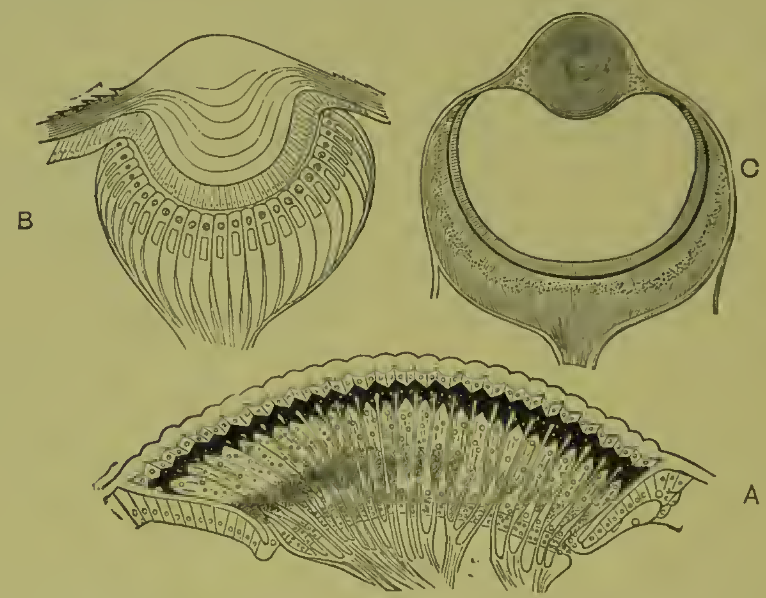


Fig. 1058.—Sections through the Compound Eye of an Earwig (*Forficula*, A), and the Camera Eyes of a Spider (*Epeira diadema*, B), and a Marine Annelid (*Alciope*, C), enlarged

In A numerous radiating visual pyramids are seen, ending externally in the facets of the thickened cuticle, and connected internally with nerve-branches; one of the pigmented zones is indicated. In B the cuticle is thickened into a rounded lens, and behind this is a transparent layer, upon which abut the retinal cells, continuous with nerve-fibres; each retinal cell contains a refracting rodlet. C is a vesicle, of which the external part is thickened into a spheroidal lens, while the rest constitutes a retina, consisting of an internal refracting layer, separated by pigment from the external sensitive part, into which nerve-fibres are seen running.

Camera Eyes are found in Annelids, Arthropods, Molluscs, and Vertebrates. Just as in a photographer's camera a picture of external objects is imaged on a sensitive plate by means of a lens, so also in a camera eye do we find refracting structures which focus light-rays on a retina, or layer of sensitive visual cells. Scattering of light is prevented in the former case by a blackened lining, in the latter by a layer of pigment.

One of the two exceptionally large eyes present on the head of a marine Bristle-Worm (*Alciope*) is represented in fig. 1058. A Sea-Centipede (*Nereis*) possesses four smaller and less complex eyes of similar kind on the upper side of its head-lobe, and in some of the tube-inhabiting Bristle-Worms (*e.g. Branchiomma* and

Dasychone) there are eyes of elaborate nature on the gill-filaments of the head.

Spiders, among Arthropods, have a group of simple eyes (ocelli) on the top of the head. These are constructed on the camera principle, though they differ in detail from those of Alciope (fig. 1058). The spherical shape of the lens and its closeness to the retina suggest that only near objects can be seen with any degree of distinctness. A great many Insects possess ocelli in addition to the two large compound eyes. In Bees, for instance, there are three of these arranged in a triangle on the top of the head. In this and similar cases it is extremely probable that the compound

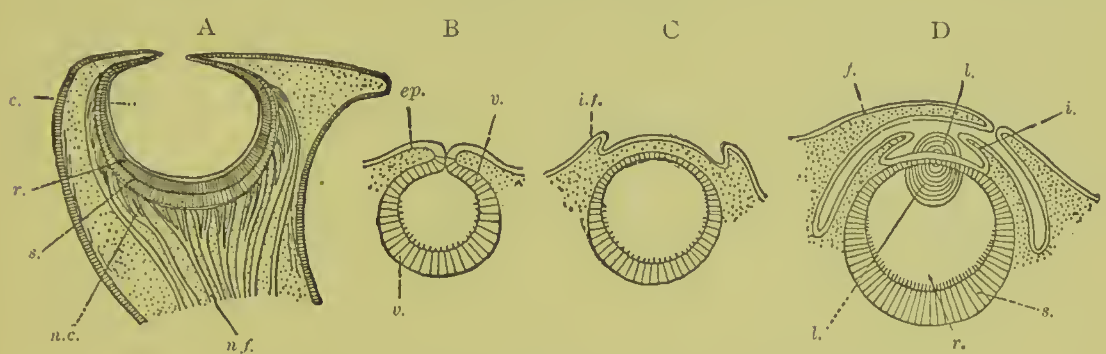


Fig. 1059.—Diagrammatic Sections through Camera Eyes of Cephalopods

A, Eye of Nautilus; *c.*, internal cavity; *r.* and *s.*, refracting and sensitive layers of retina; *n.c.*, layer of nerve-cells; *n.f.*, nerve-fibres. B–D, Stages in development of eye of Cuttle-Fish (*Sepia*); in B the epidermis (*ep.*) has folded in to produce a vesicle (*v.*, *v.*); in C a fold (*i.f.*) is growing out to form the iris; D is the adult eye; *f.*, protective external fold; *i.*, iris; *l.*, *l.*, outer and inner parts of lens; *r.* and *s.*, refracting and sensitive layers of retina.

eyes are used for seeing things at a distance, while the ocelli are used at close range. As focussing arrangements are entirely absent this would certainly be a great convenience.

The most familiar example of camera eyes among Molluscs is afforded by the Garden-Snail (*Helix aspersa*, fig. 1038), where they are placed near the tips of the long front tentacles. It is extremely short-sighted, as we might expect, in view of the fact that the lens is practically spherical and very close to the retina. The Pearly Nautilus possesses eyes which are constructed on the "pinhole camera" principle. There is no lens, and sea-water is admitted by a minute hole into the large internal cavity (fig. 1059). Large and complex eyes are found in the rapacious Squids and Cuttle-Fishes, and some idea of their structure and mode of development will be gathered from fig. 1059. A few of the Bivalve Molluscs possess numerous complex camera eyes situated on the edges of the mantle-flaps, as in the Scallops (*Pecten*), where they

are bright-red in colour. Their presence is possibly in relation to the fact that some species are active swimmers.

Before speaking of the camera eyes of Vertebrates, it may be well to mention certain simpler visual structures which are found in some of the most primitive members of that group. In the tadpole larva of a Sea-Squirt there is a simple cup-like direction-eye formed by thickening of the wall of the brain, and projecting into that organ (see fig. 1049, p. 38). Since the larva is transparent light-rays are able to reach it. The adult condition results from a remarkable series of modifications (see vol. iii, p. 421), which include simplification of the nervous system with loss of the brain-eye and brain-otocyst. The only compensation for this loss of vision consists in the appearance of a circlet of pigmented eye-spots round the openings by which currents of sea-water enter and leave the body.

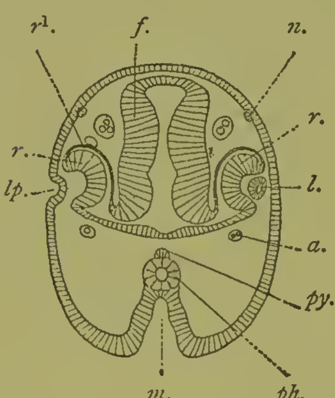


Fig. 1060.—Diagrammatic Cross Section through the Head of a Tadpole, to Illustrate the Development of the Eyes, enlarged. *f.*, Fore-brain; *r.* and *r¹.*, retina and its external pigment-layer; *lp.*, lens-pit; *l.*, lens; *a.*, an artery; *m.*, mouth cavity; *n.*, a nerve; *ph.*, pharynx; *py.*, pituitary body.

The visual organs of the transparent Lancelet (*Amphioxus*) are of even simpler kind. The so-called "eye" is merely a deeply-pigmented spot in the extreme front end of the nerve-tube, and there is in addition a series of similar but smaller spots in the floor of the nerve-tube behind the head-region.

The facts just mentioned prepare us for the statement that the ordinary camera eyes of Fishes and still higher Vertebrates are partly derived from the brain, and in this they differ from the camera eyes of Invertebrates, which are of epidermic nature. Two stages in the development of the Vertebrate eye are represented in fig. 1060. From either side of the fore-brain of the embryo an *optic vesicle* grows out towards the ectoderm, in which a corresponding pit makes its appearance. The end of the vesicle becomes as it were pushed in to form a double-walled *optic cup*, of which the inner and thicker layer is destined to produce the greater part of the retina, or sensitive eye-screen, while the outermost pigmented layer of this is derived from the outer part of the cup. The external ectodermic pit closes, and is pinched off as a vesicle, which lies in the optic cup (see right-hand side of figure), and ultimately thickens into the lens. The stalk of the optic cup becomes the

optic nerve. Since the brain itself is of ectodermic origin (see p. 20), it is clear that the parts of the eye so far mentioned are all derived from ectoderm. The rest of the eyeball, including its two outer coats and refracting contents (see vol. i, p. 57), are formed from the middle embryonic layer (mesoderm). This curious kind of development clearly suggests that in the remote ancestors of Vertebrates the eyes were internal projections from the brain, and received their light through the transparent tissues external to them, as is still the case in the single eye of the tadpole of a Sea-Squirt. The free ends of the visual cells (rods and cones) were directed towards the cavity of the brain. As in the course of evolution the brain became more and more complex, an opaque skull was developed for its protection, and the brain-eyes, having their supply of light thus cut off, were obliged, so to speak, to grow outwards. Subsequently they were improved into camera eyes by the development of a lens. Further improvements consisted in the evolution of eye-muscles, eyelids, and complex focussing arrangements. The visual cells (rods and cones) of the Vertebrate eye present the remarkable peculiarity of pointing *away* from the light, one result of the manner in which the retina is developed.

Fig. 1061. — Section through the Pineal Eye of a Tuatara (*Hatteria*), enlarged. *f.*, Fibrous covering; *l.*, lens; *r.*, *r.*, retina; *b.*, blood-vessel; *o.n.*, optic nerve.

In Vertebrates, such as Fishes, which have to see under water, the lens of the eye is spheroidal, and one mark of the aquatic ancestry of the Amphibia is the possession of a lens of similar shape. But thoroughgoing land Vertebrates have lost this primitive character, for in them the lens is more or less flattened and biconvex, as an adaptation to seeing in air.

An extremely interesting and remarkable arrangement is found in certain bony fishes known as Double-Eyes (*Anableps*), native to the coasts and estuaries of tropical America. The name has been given because either eye, as seen from the exterior, is marked off into upper and lower halves by a dark transverse band. Dissection shows that the upper half of the lens is biconvex, and the lower half spheroidal. And since these fishes habitually swim at the surface, with only the lower part of the eye immersed, we can

only conclude that this half can see clearly in water, while the upper half has been so modified that distinct vision in air has also become possible.

Some of the Reptiles possess a more or less degenerate third or *pineal eye* on the top of the head (fig. 1061). It is connected with the roof of the 'twixt-brain. There seems good reason to believe that the ancestral Vertebrates had at least one visual organ in this position, probably serving as a means of detecting enemies attacking from above, a contingency to which aquatic forms are peculiarly liable. We may perhaps compare it with the internal brain-eye of the Ascidian tadpole, which also is unpaired and dorsal.

ANIMAL INSTINCT AND INTELLIGENCE

CHAPTER LIX

GENERAL PRINCIPLES—INSTINCT AND INTELLIGENCE IN HIGHER INVERTEBRATES AND VERTEBRATES

GENERAL PRINCIPLES

Having briefly surveyed the salient facts regarding the Nervous System and Sense-Organs we naturally pass on to the consideration of those higher manifestations of life known as Instinct and Intelligence, which play a very important part in the adjustment of animals to their surroundings. To do anything like full justice to the subject at least half a volume would be required, and it is only possible here to attempt a brief summary of general principles, adding to this a few typical illustrations. Many other examples, however, will be found in other parts of this book. As regards the present section, the writer wishes to acknowledge his great indebtedness to the works of Principal Lloyd Morgan, *i.e. Habit and Instinct*, *Animal Life and Intelligence*, and *Animal Behaviour*, to which are referred those readers who wish further information on this branch of zoology.

Something has already been said about Reflex Actions (see p. 9), which are comparatively simple responses to external stimuli. In very lowly animals, such as Animalcules (Protozoa), these, together with equally simple spontaneous actions, are sufficient to meet all the contingencies of existence. So apparently purposeful, however, are many of these actions, that some observers are inclined to ascribe mental powers to such forms. Either to prove or to disprove such a view is impossible, for we have no direct knowledge of the mind of any animal save Man, and can only make more or less probable guesses about other forms. We may feel pretty sure, however, that the evolution of the nervous

system through increasingly complex stages has been associated with a corresponding evolution of mind, and there is considerable justification for doubting whether animals devoid of a nervous system, or possessed of a very imperfect one, are endowed with more than a dim consciousness or awareness of existence, or are capable of manifesting either Instinct or Intelligence.

An animal which inherits the power of performing more or less complex actions helping to adjust it to its surroundings, independently of experience or instruction, is said to display Instinct, and such actions may be termed instinctive. They differ from Reflex Actions in being more elaborate, and many of them are partly or entirely spontaneous. But our knowledge is at present too incomplete to enable us to draw the line between actions which are of reflex character and those which are instinctive. It is only when dealing with the higher Invertebrates and the Vertebrates that we can use the latter term with any degree of certainty. The Birch-Weevil (see vol. iii, p. 394), for instance, certainly displays instinct when she constructs an elaborate leaf-funnel for the reception of her eggs. This very complicated piece of work is performed, so far as we know, with unerring certainty and without previous experience. Nor can the weevil have more than a hazy knowledge of the purpose of her work, which is probably done quite mechanically.

An animal is said to show Intelligence when it profits by experience, accommodating its actions to the exigencies of changed or changing surrounding. There is an inherited basis to such actions; it is the controlling power which makes them intelligent. The difference between Instinct and Intelligence is explained with admirable lucidity in the following passage from Lloyd Morgan (in *Animal Behaviour*):—"Such an animal as a newly-hatched bird or an insect just set free from the chrysalis is a going concern, a living creature. It is the bearer of wonderfully complex automatic machinery, capable, under the initiating influence of stimuli, of performing instinctive acts. But if this were all, we should have no more than a cunningly-wrought and self-developing automatic machine. What the creature does instinctively at first it would do always, perhaps a little more smoothly as the organic mechanism settled down to its work—just as a steam-engine goes more smoothly when it has been running for a while; but otherwise the action would continue unchanged. Instinctive behaviour would

remain unmodified throughout life. The chick, however, or the imago insect, is something more than this. It affords evidence of the accommodation of behaviour to varying circumstances. It so acts as to lead us to infer that there are centres of intelligent control through the action of which the automatic behaviour can be modified in accordance with the results of experience. When, for example, a young chick walks towards and pecks at a lady-bird, the like of which he has never before seen, the behaviour may be purely instinctive; and so, too, when he similarly seizes a wasp-larva. . . . But when, after a few trials, the chick leaves lady-birds unmolested while he seizes wasp-larvæ with increased energy, he affords evidence of selection based on individual experience. And such selection implies intelligence in almost its simplest expression. We may say, therefore, that, whereas instinctive behaviour is prior to individual experience, intelligent behaviour is the outcome and product of such experience. This distinction is presumably clear enough; and it is one that is based on the facts of observation. But we must not fail to notice that, though the logical distinction is quite clear, the acquired modifications of behaviour, which we speak of as intelligence, presuppose congenital [*i.e.* inherited] modes of response which are guided to finer issues. We may say then, that where these congenital modes of response take the form of instinctive behaviour, there is supplied a general plan of action which intelligence particularizes in such a manner as to produce accommodation to the conditions of existence." The quotation just given implies, what is no doubt true, that in the course of mental evolution Instinct does not *become* Intelligence, but is gradually *replaced* by it, *i.e.* inherited specialized behaviour is replaced more or less by self-specialized behaviour. The larger the amount of such replacement the greater the intelligence. And this enables us to understand the peculiar helplessness of the young of higher Mammals, especially those of our own species. The complex instincts of lower forms have been lost, and it takes a long time to learn how to act intelligently. The remark does not apply to all helpless young, for in some of these, *e.g.* in nestling birds, such instincts are only deferred. The influence of strongly-developed parental affection is noticeable in both cases.

To interpret the action of animals with any likelihood of accuracy it is necessary to avoid two extreme views of opposite kind. One of these ascribes almost human attributes to even the

lowest animals; it is a case of interpreting the observed in terms of the observer. The other and older view regards Man as the only intelligent animal, all the others being simply living machines worked by Instinct and Reflex Action. There has been in the past a great dearth of patient unbiassed observation on living animals, but the number of competent investigators is now fortunately increasing, and the results already obtained clearly point to the conclusion that extreme opinions in either direction are inadmissible.

The difference between Instinct and Intelligence may also be realized by taking some metaphorical illustration. Let us then compare the successful adjustments of an animal to its environment to the effective shots of a rifleman aiming at a series of targets. And let us also suppose that a certain minimum score is necessary for the maintenance of a bare existence, while marriage is only permitted as the reward of a good score. The shooting of such a rifleman would be comparable to the actions of an animal actuated by pure Instinct, if he were provided with a series of loaded rifles previously sighted and adjusted in such a way that he would merely have to press the triggers to mechanically secure a large number of points—a sort of "you-press-the-button-and-we-do-the-rest" arrangement. If the targets remained fixed the privileges attached to success would be easily secured. But the actions of life have to bring about adjustments to surroundings which are constantly altering, and this may be represented in the illustration by substituting moving targets for stationary ones. The purely "instinctive rifleman" would do pretty well if his targets moved but slightly, though bull's-eyes would be infrequent, and his total would be smaller. But with increasing movement the percentage of hits would dwindle till first of all the prize of matrimony would be denied him, and finally the score would be so small that even bare existence would not be permitted.

Our illustration can easily be modified to represent the gradual replacement of Instinct by Intelligence. By endowing our imaginary rifleman with increasing capacity to adjust his rifles, so as to secure a reasonable score with shifting targets, we make his shooting more and more intelligent, less and less instinctive. And were he simply given the loaded rifles, and left to learn the art of marksmanship for himself, success would require a high degree of intelligence. The loaded rifles would represent the gift of inheri-

YOUNG ORANG-UTANS (*Simia satyrus*

The Orang-utan, a man-like ape native to Sumatra and Borneo, is characterized by the great relative length of its arms, a peculiarity associated with purely arboreal habits. The long hair is of a reddish colour. Orangs are undoubtedly very intelligent, and the rounded intellectual-looking forehead gives a very human appearance. The mental powers of the Gorilla and Chimpanzee, however, are more considerable, though the powerful brow-ridges which these forms possess greatly detract from their personal appearance.

The Orang builds a kind of stick-nest in the fork of a tree as a temporary shelter, from which it does not sally forth to feed until the day is well advanced. Small family parties are commonly found associated together, though the male appears to lead a solitary life during a large part of the year. The young are as helpless as those of the human species, and those which have been brought up in captivity present many similar traits. Their wants are expressed by loud lamentations, and they protest loudly if their food is not to their taste. They also greatly appreciate being nursed and "cuddled". Unlike human infants, however, they are eager to be washed and combed.

YOUNG ORANG-UTANS (SIMIA SATYRUS)

tance; but were there no profiting by experience most of the shots would go wide. Parental care might be here symbolized by supposing the raw beginner protected and instructed by an expert shot until the necessary experience had been acquired.

We do not know how far down in the scale of animal life some sort of consciousness exists, but the dawn of intelligence is marked by the appearance of what Lloyd Morgan calls "effective consciousness", *i.e.* a realization of existence which enables more or less successful adjustments to a changing environment.

In ourselves we find Intelligence reinforced by Reason, the "ideational stage" in mental evolution, where actions depend upon motive, instead of being due to mere impulse dictating certain sorts of behaviour "on the spur of the moment". It involves appreciation of abstract ideas with powers of reflection and deliberation, leading us to trace the relations between cause and effect, and to construct ideals of existence by which our conduct is more or less regulated. The dim beginnings of Reason are probably to be found among the higher animals, but the body of facts with which we are at present acquainted is far too small to justify positive statements or wide-sweeping generalizations.

INSTINCT AND INTELLIGENCE IN HIGHER INVERTEBRATES (INVERTEBRATA)

The most instructive cases so far investigated are to be found among Insects (Insecta) and Molluscs (Mollusca), and it will be enough for our present purpose to briefly describe a few of these.

INSTINCT AND INTELLIGENCE IN INSECTS (INSECTA).—A good example of the stereotyped nature of complex instincts is given by Fabre (in *Souvenirs entomologiques*) in his account of one of the Mason-Bees (*Chalicodoma muraria*) native to South Europe. The female makes a nest consisting of nine or ten cells placed one on top of the other, using cement made of a mixture of earth and saliva, to which little stones are added. After each cell is built it is stored with honey and pollen, after which an egg is laid in it, and a roof is added. The entire series is then thickly covered with cement till the nest assumes a hemispherical form. The three operations of building, storing, and egg-laying which take place in regard to each cell follow one another with automatic regularity, and there is no harking back to an earlier stage. For conditions

artificially imposed with a view to altering the order do not succeed in this, as they would do if the actions were of very intelligent kind. For example, a nest with fully-constructed top-cell partly stored was substituted for the original nest in which the uppermost cell had only been commenced. The bee did not apparently detect the imposture, and proceeded to raise the walls of the substituted cell till it was one-third greater than the normal height. In another experiment a bee had completed the construction of a cell, and was preparing to store it, when another nest with an incomplete top-chamber was substituted. On her return with honey and pollen she appeared greatly puzzled at the change, and finally deposited her load in the nest of a neighbour. The result of another similar experiment was somewhat different, for the bee removed the roof of the last complete cell and stored this a second time, afterwards laying a second egg in it. The last two experiments seem to prove the existence of a certain infusion of intelligence, as shown by the attempts to meet the altered circumstances, though these attempts were not of very satisfactory kind. It is somewhat remarkable that this bee is apparently unable to recognize its own nest, though we must not forget that its visual powers are of different kind from our own, but it has a well-marked memory for localities, returning to the spot selected for building-purposes from considerable distances. Fabre also showed that individuals removed as far as four kilometres from their nests, into what was probably unknown country to them, were able to find their way home. Quite a number of animals are endowed with a strong "homing faculty" of this kind, but how far this may be due to a "locality sense" which cannot be explained by applying the known principles of human physiology, it is as yet impossible to say. In this particular instance, even if we were to assume that the bees had some previous acquaintance with the distant place to which they were taken, we should still be quite unable to explain exactly *how* they got home. Locality-memory, however, would seem to imply some amount of intelligence. Readers desiring further details of the fascinating observations and experiments by Fabre on Mason-Bees and many other insects are referred to the original work, or the translation of the same which has recently appeared.

Suggestions have more than once been made in the course of this book as to the kind of investigation which amateur naturalists

might profitably attempt. The habits of Insects and other higher Invertebrates offer an inexhaustible and intensely-interesting field to multitudes of such workers. Accurate observations recorded with scrupulous exactness are here badly needed, and those who enlarge our knowledge in this direction are contributing to the advance of two branches of knowledge, zoology and the science of mind (psychology), not to mention sociology and education, both of which are intimately connected with the latter.

It is indispensable that observations on instinct and intelligence should be made with a perfectly open mind, and not with the object of collecting material for the support of this or that view. And it is peculiarly necessary to remember that the mental standard of human beings can only be applied with many reservations in explanation of the actions of animals, especially when dealing with creatures like Insects which, though of highly complex structure, have specialized on lines of their own. A series of observations made in this spirit, and which are not only of the utmost value but of absorbing interest, have been recorded by Dr. and Mrs. Peckham (*On the Habits and Instincts of the Solitary Wasps*). These insects have attracted much attention on account of their habit of storing up caterpillars, flies, spiders, &c., for the benefit of their progeny, the victims having previously been stung (see vol. iii, p. 391). Instincts of very complex nature are here involved, but the zoologists just mentioned have shown that these instincts are not so stereotyped as commonly supposed, there being a certain amount of adaptability to circumstances, which is strong presumptive proof of some degree of intelligence. Pure instinct is manifested by the fact that any particular species of these wasps is always found to select the same kind of prey, and, for a given species, there is so much uniformity in the mode of nest-construction, the way of disabling the victims, the manner of taking them into the nest, &c., that instinct is undoubtedly the dominant factor. But, except in regard to the kind of prey, there is a sufficient amount of adjustment to varying circumstances to warrant the conclusion that intelligence also plays some part in the complex series of operations. It appears, for example, that the prey is not uniformly stung in the nerve-cord, as once believed, and it may be killed instead of paralysed by its injuries, proving in either case suitable food for the larvæ. This certainly discounts the view that this part of the series of actions is stereotyped by instinct.

And a convincing proof of the power of profiting by experience which constitutes intelligence is given in a letter of Dr. Peckham's, quoted by Lloyd Morgan (in *Animal Behaviour*), in reference to a species (*Sphex ichneumonea*) which preys upon grasshoppers, and after leaving them a short time while she makes an excursion into the nest, returns and drags them in by their feelers. One individual, being several times thwarted in her storing work by removal of the victim to a short distance when she was in the nest, soon learnt the inadvisability of losing sight of her booty, and either at once dragged it into the hole or, straddling over it, substituted pushing for pulling.

One of the most remarkable points about the nesting-instinct in so many solitary insects is the elaborate provision made for the welfare of offspring which will never be seen, and which commonly require food of quite different nature from that taken by the adult. The parent would seem to be urged on by irresistible impulses, and can hardly be supposed to realize the meaning of its work, except perhaps in a very dim sort of way. Butterflies and Moths illustrate the food-question very clearly. It is true that they do not construct and store nests, like the solitary wasps just mentioned, but they instinctively lay their eggs on special sorts of plant, upon the leaves of which their voracious offspring are destined to feed. A Peacock Butterfly (*Vanessa Io*), for example, selects a nettle for the purpose, but her own food consists of nectar drawn from the recesses of flowers by means of suctorial mouth-parts, differing greatly from the powerful biting jaws of the leaf-eating caterpillar. It is almost impossible to believe that remembrance of her own larval days guides to the choice of a suitable place for egg-laying, for the caterpillar is converted into the adult by a series of revolutionary changes which amount to reconstruction.

Instinct and Intelligence in Molluscs (Mollusca).—Comparatively few observations have been made upon the members of this group, some of which are very highly organized. Several good illustrations of both instinct and intelligence have, however, been recorded.

The Octopus is one of the highest Molluscs, and appears to be a very intelligent creature. Schneider saw a young one seize a hermit-crab and then let it go, being stung by the zoophytes covering its shell. For some time at least this individual was observed to avoid hermit-crabs, having learnt to associate them

with painful sensations. Other Octopi manifested still greater intelligence, for they pulled hermits out of their shells, taking care not to touch the zoophytes, realizing apparently that these were the stinging element. More remarkable than this is an observation made by Madame Jeannette Power. This lady on one occasion saw an Octopus, that held a stone by one of its arms, watching a large bivalve (*Pinna*) of which the shell was beginning to open. When this operation was complete the Octopus quickly inserted

Fig. 1062.—A Limpet (*Patella vulgata*) leaving its Scar at Ebb-tide

the stone between the valves so as to prevent them from coming together again, and then proceeded to make a meal of the helpless bivalve.

Some of the Gastropods possess a well-marked "homing instinct", a particularly good example of this being afforded by the Common Limpet (*Patella vulgata*, fig. 1062). As elsewhere described (see vol. ii, p. 197) this creature lives on a particular spot, which in course of time becomes a more or less well-marked "scar", to which it can hold so firmly as to defy waves and tide. From this home it wanders out to feed when uncovered by the water, and also when well covered. From such excursions, which may extend to a distance of several feet, it later on returns to settle down again on the scar, the surface

traversed being often very irregular and covered with acorn-barnacles. When the animal gets back to the scar it of course arrives wrong way on, so to speak, and it quickly shuffles round so as to get into the proper position. A memory of locality certainly exists, and this would seem to imply intelligence. In the course of time a Limpet acquires a very accurate knowledge of the topography of a fair-sized area around its home, and if picked up when on the crawl and placed within this area is able to get home, though the time taken varies considerably. Exactly *how* it gets home we do not know. The simple cup-like eyes cannot render assistance, nor can we very well suppose that the otocysts help to guide it. Experiments appear to demonstrate that the animal does not smell its way back, and we are therefore reduced to touch, or to a "locality sense", or to both. The most obvious organs of touch are the two large tentacles on the head, with which the Limpet constantly touches the rock as it crawls, and it is no doubt by means of these that a good deal of the topographical knowledge is acquired. But as it can get home without the aid of these organs there must be some other organs of guidance. The edge of the mantle-flap is provided with a very large number of small tentacles which can be stretched out and actively moved, as they are sometimes, if not always, when the animal is adjusting itself on its scar. These perhaps have something to do with the matter, and so may still other sense-organs, but further investigation is required. The problem here to be solved, like most of those connected with locality-knowledge, is of a particularly baffling kind, though not to be regarded as insoluble. The Garden-Snail (*Helix aspersa*) is another Mollusc possessed of a "homing instinct"

INSTINCT AND INTELLIGENCE IN VERTEBRATES (VERTEBRATA)

There is here an almost unlimited amount of material which might be discussed, but a few examples must suffice.

WARNING COLORATION.—A large number of animals possessed of noxious properties advertise their objectionable nature by means of bright though somewhat crude colours, and simple but striking patterns, the net result of which is to render them extremely conspicuous (see vol. ii, p. 301). Such are the

striped "blazer" of the Wasp, and the spotted jacket of the Lady-Bird. Unless very hard pressed by hunger it appears that the foes of animals so coloured and marked give them a wide berth. But without careful observation and experiment it would remain an open question whether this resulted from Instinct or Intelligence, or a mixture of the two. The cases which have so far been properly investigated appear to prove that Intelligence here comes into play, and that a young animal has to learn from experience that some things are good to eat and others not. The thorough and long-continued researches of Lloyd Morgan upon artificially-hatched chicks definitely prove that they at least have to acquire such useful knowledge for themselves. He thus describes (in *Animal Behaviour*) how some of his chicks learnt that alternate bands of black and orange, as possessed by the caterpillars of the Cinnabar Moth, are associated with disagreeable sensations:—"The following experiment was made with young chicks. Stripes of orange and black paper were pasted beneath glass slips, and on them meal moistened with quinine was placed. On other plain slips meal moistened with water was provided. The young birds soon learnt to avoid the bitter meal, and then would not touch plain meal if it was offered on the banded slip. And these birds, save in two instances, refused to touch cinnabar caterpillars, which were new to their experience. They did not, like other birds, have to learn by particular trials that these caterpillars are unpleasant. Their experience had already been gained through the banded glass slips; or so it seemed. I have also found that young birds who had learnt to avoid cinnabar caterpillars left wasps untouched."

Nest-Building in Birds.—There can be no reasonable doubt that in its main features the nest-building of birds is a matter of instinct. One of the best proofs of this is afforded by cases where individuals kept in captivity from the time of hatching, under conditions which excluded the possibility of instruction or imitation, have nevertheless constructed nests of the kind proper to their species. Further experiments, however, are much to be desired, especially on birds which indulge in architecture of such characteristic kind as to be quite unmistakable. It would, of course, be necessary to make the nesting conditions in such cases as natural as possible. Other instincts, tending to the benefit

of the eggs or young, are often associated with that for nest-building. Of this the Eider-Duck (*Somateria mollissima*, fig. 1063) may be taken as an example. Egg-laying and building are here not consecutive acts, but the former takes place at intervals during the latter, in a somewhat variable fashion. Three successive stages are shown in the illustration, which is taken from photographs by Mr. R. A. L. Van Someren. The first represents four eggs resting in the incomplete nest, and the second (on a larger scale) the complete down-lined nest with its full complement of eggs. The third figure shows the same nest during the temporary absence of the mother-bird, and illustrates an interesting associated instinct. Before leaving her duties she had pulled the down over the eggs, so as to cover them completely, an act distinctly conducive to their welfare. For, snugly tucked up under their "eider-down quilt", they were not only kept warm, but also, as the figure clearly proves, effectively screened from observation.

Fig. 1063.—Nest of the Eider-Duck (*Somateria mollissima*). See Text.

But although nest-building is almost certainly instinctive in the main, it is subject to modification in individual cases in ways which vouch for the intelligence of the builders. And such modification may affect the style, materials, and place of construction. Often-quoted illustrations are those of the House-Swallow and House-Martin, which have taken advantage of the evolution of human civilization so far as concerned with domestic architecture.

This change of habit, of course, took place in the remote past, but the following very interesting modern example of precisely similar kind is given by Headley (in *The Structure and Life of Birds*):—"The Palm Swift in Jamaica till 1854 always built in palms. But in Spanish Town, when two cocoa-nut palms were blown down, they drove out the Swallows from the Piazza of the House of Assembly and built between the angles formed by the beams and joists." Of other such cases Newton thus writes (in *A Dictionary of Birds*):—"But though in a general way the dictates of hereditary instinct are rigidly observed by Birds, in many species a remarkable degree of elasticity is exhibited or the rule of habit is rudely broken. Thus, the noble Falcon, whose ordinary eyry is on the beetling cliff, will for the convenience of procuring prey condescend to lay its eggs on the ground in a marsh, or appropriate the nest of some other bird in a tree. The Golden Eagle, too, remarkably adapts itself to circumstances, now rearing its young on a precipitous ledge, now on the arm of an ancient monarch of the forest, and again on a treeless plain, making a humble home amid grass and herbage. Herons also show the same versatility, and will breed according to circumstances in an open fen, on sea-banks, or (as is most usual) on lofty trees. Such changes are easy to understand. The instinct of finding food for the family is predominant, and where most food is, there will the feeders be gathered together. This explains, in all likelihood, the associated bands of Ospreys or Fish-Hawks, which in North America breed (or used to breed) in large companies where sustenance is plentiful, though in the Old World the same species brooks not the society of aught but its mate."

Migration of Birds.—Nothing can be more familiar than the fact that innumerable species of birds undertake periodic journeys, often of extreme length, from one region to another, and at the same time nothing in the entire realm of natural history is more mysterious. Broadly speaking, the same migrant species has its own line of travel between its two places of residence. The Golden Plovers, for example, of the northern part of North America, fly south to the north of South America *via* the Bermudas and Antilles. The paths of a number of species are more or less coincident, in many cases, to form what is known as a "migration route", and some of these routes

have been determined with some approach to accuracy. A vast number of facts concerning migration have already been collected, and these receive large additions every year, so that in the course of time we may expect to have a fairly complete knowledge of the movements of many migratory birds. To discover *how* they find their way is a much more difficult problem, especially in cases where there can have been no previous experience. Many of them, *e.g.* the Common White Stork (*Ciconia alba*), "assemble" before migration, as if to practise their powers of flight, and the writer once saw the roof-ridges in the street of a midland town "lined" with hundreds of swallows at 6 a.m. one morning, less than two hours after which all had disappeared. It has been suggested that the old birds impart geographical knowledge to the young, and also that the migrant flocks are "personally conducted" by experienced leaders. But many well-ascertained facts militate strongly against such views, at any rate for certain species. Some young birds go off by themselves, even the first time they migrate, and this may take place under conditions which preclude the possibility of their having previously acquired information from their elders. The Common Cuckoo (*Cuculus canorus*), for example, winters in Africa, and, as everyone knows, its offspring are reared by other birds. The old Cuckoos have all left this country by the end of August, and the young ones take their departure later. In such a case we cannot doubt the existence of a "migratory instinct", but how far this is modified by intelligence has yet to be determined. We are equally ignorant as to the sense-organs which are the agents of the instinct, and its possible modifications by intelligence, even more than we are in the cases of insects and molluscs which possess a keen sense of locality. We ourselves are not entirely devoid of a faculty of the kind, and it appears to be comparatively well developed in savage races. It is to be hoped that extended observation and experiment will some day throw more light upon the subject, till when it will be wise to suspend our judgment, and remain in a critical attitude, rather than indulge in premature generalization. It is scarcely necessary to add that there is room for a host of unprejudiced observers in this field of work.

WHITE STORKS (*Ciconia alba*) ASSEMBLING FOR MIGRATION

The seasonal Migration of many birds is a phenomenon familiar to all, and one which, in spite of much research, is still but little understood. Food-supply has no doubt much to do with it, but the reasons for migration are the least mysterious part of the matter. *How* birds are able to find their way over vast stretches of land and sea to regions suitable for their purposes is at present quite beyond our comprehension. In most cases it appears that the young birds are the first to depart on what must be for them an unknown journey, which greatly adds to the difficulty of the problem to be solved. One of the best-known migratory birds is the White Stork, the rough stick-nests of which are such common objects on roofs and chimneys in Holland, Denmark, and North Germany. The locality-sense is strongly developed, for year after year a nest is tenanted by the same pair of birds. They arrive in spring, leaving again in late summer, by which time the young are well grown. Before their departure they "assemble" in large numbers on the meadows, and fly away in troops, some of which have been estimated to include as many as five thousand individuals. They winter in Africa, some of them getting as far south as Cape Colony.

WHITE STORKS (CICONIA ALBA) ASSEMBLING FOR MIGRATION

ASSOCIATION OF ORGANISMS—THE WEB OF LIFE

CHAPTER LX

ASSOCIATION OF ORGANISMS—GENERAL PRINCIPLES—ANIMALS AND PLANTS

GENERAL PRINCIPLES

The study of natural science during the last half-century has advanced so rapidly that it is no longer possible for one man to grapple seriously even with a single subject, and there is an ever-increasing tendency towards specialization. No doubt the sum of our knowledge is thereby constantly being increased at a rate which would otherwise be impossible, but there is another side to the question. For extreme specialization is somewhat apt to lead to a neglect of general principles, and to a more or less complete loss of the sense of proportion. To be unable to see the wood on account of the trees is bad enough, but to have one's vision restricted to a single tree, or perhaps a single branch, is very much worse. In no department of knowledge is the cramping tendency of specialization more apparent than in natural history. There seemed at one time a chance of establishing a science of Biology, designed to deal with both plants and animals, but this has now been merged into botany on the one hand and zoology on the other, and many of the important relations that exist between plants and animals are not given the prominence which they undoubtedly deserve. This cannot altogether be helped, but even under existing circumstances it is both desirable and possible that work of specialist kind should be preceded by studies of a wider and more general nature. This is one of the aims of the new subject of Nature-Study, so far as biology and geology are concerned, another object being to foster that intelligent interest in and accurate observation

of natural objects upon which much of the future happiness of our embryo citizens will depend. If properly taught as a connected whole, and not as a string of isolated facts (to be "learnt"), this subject ought to fare better than physiography and general elementary science, which, though designed with the laudable intention of giving a broad foundation in non-biological science, are now somewhat discredited.

The relations which bind together the innumerable plants and animals now living on the globe are so numerous, and often so complex, that from this point of view the world has been compared to a spider's-web of elaborate texture, in which all the threads are directly or indirectly connected, so that when one is touched the entire structure is thrown into vibration.

It is not within the scope of this work to deal with the complex relations which link together the members of the vegetable kingdom, and students who desire information of this kind are referred to the English edition of Schimper's *Plant Geography*, to Kerner von Marilaun's altogether admirable book *The Natural History of Plants*, and also to Scott Elliot's *Nature Studies*, which gives an excellent account of the leading facts and principles in small compass. But it may be well to attempt here a brief description of the salient features which mark the relations existing between plants and animals. This is much more fully dealt with by the authors just mentioned.

PLANTS AND ANIMALS

It may not be superfluous to remark here that the vegetable world is divided into the following great groups, beginning with the highest:—1. Seed Plants (Spermaphyta), including most of the large and obvious forms, such as ordinary forest-trees and the inhabitants of our flower-gardens. 2. Fern-like Plants (Pteridophyta), comprising not only ferns, but also horse-tails, club-mosses, &c. 3. Mosses and Liverworts (Bryophyta). 4. Lower Plants (Thallophyta), in which the body is not divided into stem, root, and leaf, or such a division is only incipient. Multitudes of Thallophytes are minute or microscopic, and in any case they may broadly be assigned to one of three sub-groups: (*a*) *Algæ*, embracing brown, green, and red sea-weeds (with a smaller number of freshwater weeds), with a host of smaller

forms living not only in water but in most damp places; (*b*) *Fungi*, including toad-stools, moulds, mildews, the microscopic yeast-plants, and the still smaller bacteria; and (*c*) *Lichens*, which are intimately connected communities of algæ and fungi.

All these plants, except fungi (and a few seed-plants), contain leaf-green or chlorophyll, a substance of great biological importance, as elsewhere explained. It is convenient to distinguish forms which possess it as "green plants", though the chlorophyll

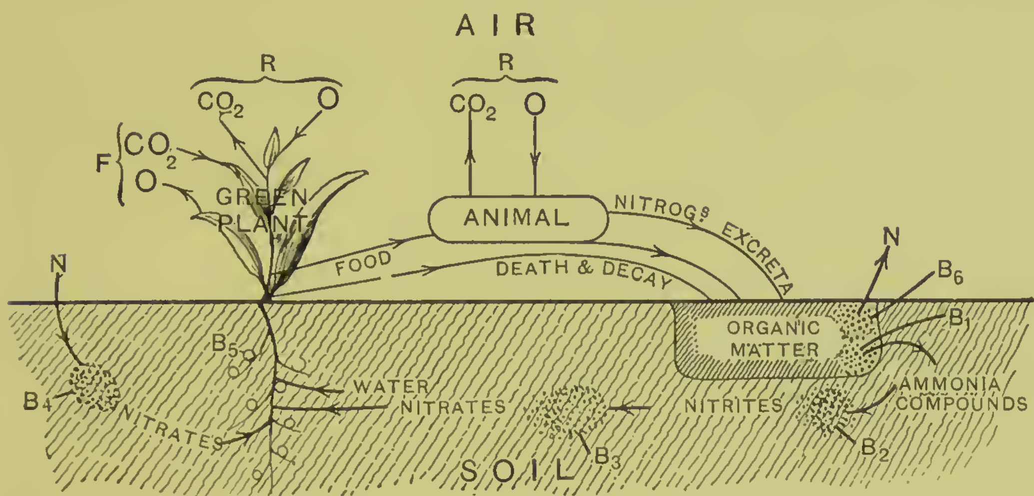


Fig. 1064.—Relations between Animals and Plants: arrows indicate the taking in or giving out of various substances

Both green plant and animal take in oxygen (O) and give out carbon dioxide (CO_2) in the course of respiration (R). The animal feeds on plants, and by nitrogenous excretion and ultimate death adds to the store of organic matter in the soil. The green plant in the course of feeding (F) takes in carbon dioxide (CO_2) from the air, returning oxygen (O), and also takes up water with dissolved salts from the soil; its dead parts contribute to the store of organic matter in the soil. The groups of bacteria B_1–B_3, respectively produce ammonia compounds, convert these into nitrites, and these again into nitrates. The bacteria B_4, and the tubercle-fungi B_5, fix the free nitrogen (N) of the air, with production of nitrates. The bacteria B_6, in the absence of oxygen, decompose organic matter with liberation of free nitrogen (N).

may be obscured by the presence of other pigments, as, for example, in brown and red sea-weeds.

Relations between Organisms and the Constituents of the Atmosphere (fig. 1064).—In considering this question it must not be forgotten that the gases which are mixed together in air are also found dissolved in both fresh and salt water, and the relations between these dissolved gases and aquatic organisms are pretty much the same as those subsisting between ordinary air and land organisms. The most important of these gases are carbon dioxide (carbonic acid gas, CO_2), oxygen, and nitrogen. It has already been explained in the section on Breathing (vol. ii, p. 379) that plants and animals respire in the same way, taking in oxygen to facilitate the breaking-down processes which continually go

on in the body, and giving out carbon dioxide as a product of waste. It is quite a mistake to suppose that plants "breathe in carbon dioxide and breathe out oxygen", as often supposed. If there were not some compensating arrangement, it is clear that the amount of oxygen in air would rapidly diminish and the quantity of carbon dioxide rapidly increase. But it appears that this is not so, for the composition of air remains practically the same, at least for very long periods of time, though probably in earlier periods of the earth's history its constituent gases were in different proportions from what is now the case. This constancy of composition at the present day is intelligible when we remember how green plants feed, and of what their food consists. Such plants, in fact, bridge over in a fashion the gulf between non-living and living matter. For their food consists of carbon dioxide (obtained from the air), and water in which are dissolved certain substances of simple kind, foremost among these being nitrogen-containing compounds known as nitrates, of which saltpetre is a well-known example. In any sort of tree, shrub, or herb the carbon dioxide is taken in by the leaves (and the green part of the stem), while the roots absorb from the soil a watery solution of nitrates, &c., so dilute as to be comparable to the ordinary drinking water of most districts. These simple constituents of the food are converted step by step into the living substance of the plant by the agency of that substance itself. The first step in this series of up-building processes takes place in the leaves (and the green parts of the stem), and consists in a reaction between carbon dioxide and water, giving rise to a substance which is more complex in nature than either of them. This can only go on in daylight and in the presence of chlorophyll, which in some way not clearly understood enables the living substance associated with it to press the energy of sunlight into its service for the purpose of building up a comparatively complex substance from simple ones. And this first step in the manufacture of living matter is accompanied by the liberation of free oxygen into the surrounding air as a by-product. For the carbon dioxide and water, which are the raw materials in this work, contain more oxygen than is required for the purpose, and the surplus passes away to the exterior. It therefore follows that green plants in the course of their feeding (1) take carbon dioxide *from* the air, and (2) give out free oxygen *to* the air. And these

gases are respectively taken in and given out in such proportions that the amount of carbon dioxide in the air does not rapidly grow larger, and the amount of free oxygen rapidly get smaller, as would undoubtedly be the case if the results of breathing were not compensated.

The action and reaction between organisms and the air also involve chemical processes which have to do with nitrogen, and in which a leading part is played by various bacteria which live in the soil. Green plants get the nitrogen which they require for feeding purposes in the form of dissolved nitrates, which are derived from more than one source. It is a familiar fact that ordinary earth or soil, such as is to be found in a garden, is more or less dark in colour, largely as the result of the presence of organic matter. This partly consists of the remains of organisms which have died and decayed, and partly of substances derived from the nitrogen-containing excreta of animals. The rotting, decomposition, or breaking down of such materials is the result of chemical changes brought about by certain bacteria in the presence of oxygen, with production of ammonia compounds. Another set of bacteria convert these compounds into salts known as nitrites, from which nitrates are then produced by the action of still another group of bacteria. The nitrates serve as food to green plants, which in their turn are devoured by animals. We thus see that by the death and decay of organisms material is produced which helps to build up the bodies of new generations. This, however, is not the only source of nitrates in the soil, for what are known as *nitrifying* bacteria are there present, which possess the remarkable power of abstracting free nitrogen from the air, and causing it to enter into combination. There is another arrangement by which, in leguminous and a few other plants, the same end is attained. If, say, a pea- or bean-plant is dug up, and the earth washed away from its roots, these will be found to bear a number of rounded thickenings. Within each such "root-tubercle" live a number of microscopic fungi (possibly bacteria) that appropriate the free nitrogen of the air which circulates in the soil, employing it to build up nitrates. We have here a striking example of Mutualism (symbiosis), *i.e.* the intimate association of two organisms for their common benefit. The leguminous plant has a supply of nitrates ready to hand, while the tubercle-fungus is sheltered, and no doubt nourished.

It is clear that by the action of nitrifying bacteria and tubercle-fungi the nitrogen of the air is steadily diminished, but here again we find a means of compensation. For there are certain *denitrifying* bacteria, which, in the absence of oxygen, act upon decaying organic matter in such a way that free nitrogen is liberated.

Relations between the Nutrition of Plants and Animals.—A little reflection will show that animals are entirely dependent upon plants in the matter of food. This is obviously so as regards purely vegetarian animals, while carnivorous forms are indirectly dependent upon the vegetable world. Many flesh-eaters feed entirely upon vegetarians, but if they prey upon other flesh-eaters, and these again upon still other carnivorous creatures, and so on, we get to plants in the end.

Plants, considered as food for animals, have been concerned in the evolution of burrowing, climbing, parachuting, and flying forms, especially the last three. (For details, see vol. iii, pp. 231, 281, 292.)

On the other hand, animals contribute to the store of plant food. For, as we have already seen (pp. 65–67), they breathe out carbon dioxide, which green plants take up, while their nitrogenous excreta and dead bodies are partly converted into nitrates, which the same plants are able to use for the purposes of nutrition.

There are also a number of Carnivorous Plants, which do not altogether rely upon simple substances as food, but are provided with "traps" for the capture and digestion of insects or other small creatures. One of Darwin's most interesting books (*Insectivorous Plants*) is devoted to these forms, some of which are native to our own country, while several others may be seen in botanic gardens. One of the simplest kinds of arrangement is seen in the Butterwort (*Pinguicula*), that is often to be found growing in damp places among our mountains. The pale-green slippery leaves are arranged in a rosette, from the centre of which violet flowers grow up. Small flies alighting on the leaves are held fast by a sticky fluid, secreted by a multitude of little knobbed hairs which project from the surface. The edges of the leaves then curl over the prey, and there is an increased exudation of the fluid in question, which acts very much like gastric juice, converting the flesh of the booty into a soluble form that is then absorbed as food. The widely distributed members of the Sundew family (*Droseraceæ*) exhibit greater specialization in

relation to the catching of insects than the Butterworts, though the means employed are essentially the same. Our native forms, the Sundews (species of *Drosera*), are fairly common in marshy places, and are often found growing side by side with the Butterwort. Here, again, the leaves are arranged in a rosette, from the centre of which rises a stem bearing a number of small flowers. The end of each leaf is thickly studded with long reddish "tentacles", shaped something like pins, upon the heads of which are little drops of sticky fluid that glisten like dew (fig. 1065). Should an unfortunate insect alight on one or more of these tentacles it sticks fast, other

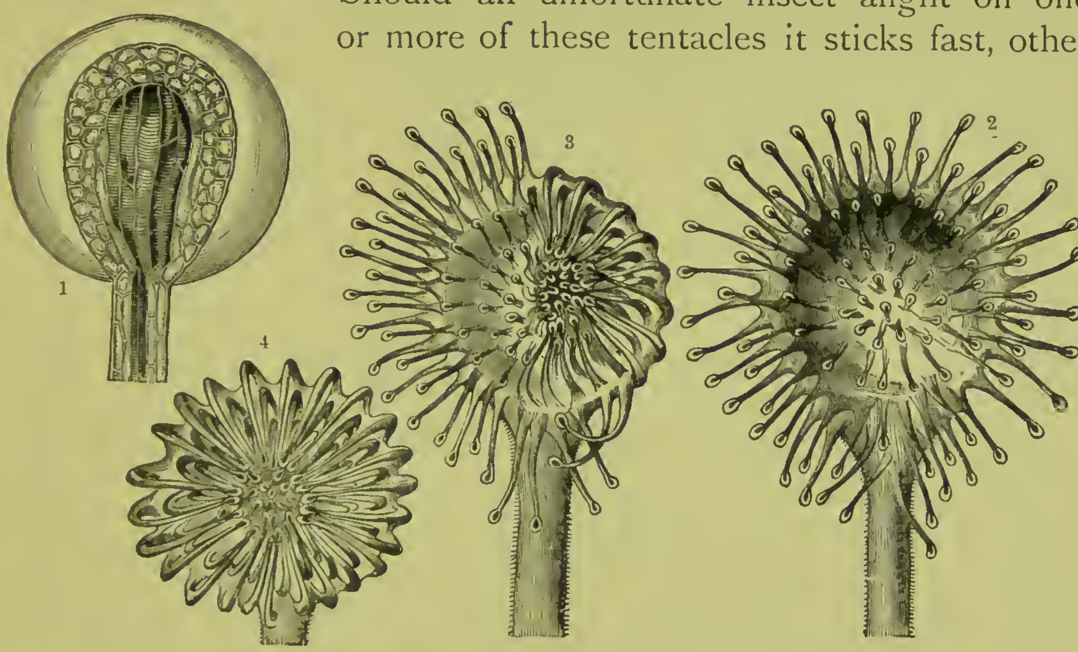


Fig. 1065.—The Sundew (*Drosera*). 1, Tip of a tentacle, greatly enlarged, showing viscid secretion. 2, 3, 4, Leaves, enlarged, showing tentacles fully extended, partly approximated, and entirely approximated.

tentacles bend towards it, there is an increased flow of the digestive juice, and the final result is the same as in a Butterwort.

Venus' Fly-Trap (*Dionæa muscipula*), growing on marshy ground in the east of the United States, is a near relative of our Sundews, but its "traps" are much more elaborate (fig. 1066). The end of each leaf is divided into halves which can move towards each other almost as on a hinge, while their edges are fringed with bristles. The upper side of each half is studded with small violet hairs, which secrete a digestive fluid, and three large sensitive hairs project from its centre. If an insect happens to visit one of these leaves, and touches one or more of the six sensitive hairs, the result is somewhat dramatic. For the halves of the leaf close rapidly together, the bristles on their edges inter-

locking, so that a very perfect trap is constituted, in which there is plenty of room for an average victim, since as the two halves move together they become concave towards each other. As in the other cases, digestion and absorption complete the tragedy.

Among the most notorious of carnivorous forms are the widely-distributed Pitcher Plants, in which the leaves are hollowed into structures which may be described as a combination of lure, pit-

Fig. 1066.—Venus' Fly-Trap (*Dionæa muscipula*)

fall, and stomach. Such are the species of *Nepenthes*, which range from Madagascar through South Asia and the East Indies to the Philippines. In this case the lidded pitchers look something like hot-water jugs, and are attractively coloured. The way in which they serve their purpose is thus described by Kerner (in *The Natural History of Plants*):—"The bright pitchers of *Nepenthes*, visible from afar, are sought, just as flowers are, by insects, and probably by other winged creatures as well; and this occurs all the more because there is a copious secretion

of honey by the epidermal cells upon the under surface of the lid, and on the rim round the mouth of each pitcher. The swollen and often delicately-fluted rim, in particular, drips and glitters with the sugary juice, and it would be permissible in this connection to speak of a honeyed mouth and sweet lips in the most literal sense of the words. Animals which suck honey from the lips of *Nepenthes* pitchers wander, as they do so, only too readily upon the interior surface of the orifice. But the inner face is smooth and precipitous, and rendered so slippery by a bluish coating of wax that not a few of the alighted guests slip down to the bottom of the pitcher and fall into the liquid there collected. Many of them perish in a short time; others try to save themselves by climbing up the internal face of the pitcher, but they always slip again on the polished, wax-coated zone, and tumble back once more to the bottom." In some species the inwardly bent rim of the pitcher is fringed with sharp teeth which curve downwards and facilitate entry but forbid exit.

Another very interesting Pitcher-Plant (*Sarracenia variolaris*), native to the marshes of Alabama, Carolina, and Florida, presents arrangements of somewhat different kind. It possesses a rosette of elongated hollow leaves, of which the ends bend sharply over like hoods. The narrow opening of a pitcher is just under the hood, from which a little flap hangs down. Allurement by colour is not wanting, for though most of each pitcher is green, its hooded top is veined with red, and there are purple blotches here and there. In this region, too, there are numerous translucent patches between the veins, which from inside the pitcher must look like openings or "windows". As in *Nepenthes*, honey is provided on the inner surface of the hood and round the margin of the aperture, from which a sugary ridge runs right down to the ground, serving as an attractive but fatal pathway to many wingless insects, especially ants. The pitcher is a pitfall of the deadliest kind, for its interior is clothed with slippery overlapping scales, of which the narrow pointed ends are directed downwards, so that insects, once imprisoned, are quite unable to climb out again. And if a winged insect tries to fly out it naturally makes for the apparent windows in the hood, for the actual opening faces downwards and is veiled in darkness, and in most cases falls back exhausted into the putrid

fluid which fills the lower part of its prison. The unfortunate victims are not digested, as in *Nepenthes*, but either drown or starve, after which their bodies decompose to form a sort of liquid manure, parts of which are no doubt absorbed as food. Yet, strange to say, a few flies, and a small moth, regularly lay their eggs in the decomposing mass contained in these pitchers, and possess climbing-irons, so to speak, which enable them to get out again with the greatest ease. One such form is a species of Blow-Fly (*Sarcophaga Sarraceniæ*), own cousin to the speckled nuisance (*S. carnaria*) that lays her eggs in our meat, and to which we give the same name. Each foot of this fly is possessed of a long and sharp claw, which can be pushed between the scales of the pitcher, and firmly fixed into the underlying tissue. The maggots which hatch out of her eggs feed on the putrefying substances surrounding them until they are full grown, when they easily get out of the pitcher, not by climbing, which would be impossible in their case, but by the simple device of eating a hole in the wall. Once outside, they enter the ground, and there pass into the motionless pupa stage, from which the adult fly later on emerges. The small moth (*Xanthoptera semicrocea*) for which the Sarracenia pitchers have no terrors is adapted for climbing in much the same way as the Blow-Fly. For each of the second legs possesses a pair of long sharp spines at the end of its shin (tibia), while two pairs of such spines are similarly situated on each of the hind-legs. The caterpillars do not, like the fly-maggots, eat their way out of the pitcher, but climb out, though in quite a different way from their mother. Their solution of the problem is equally effective, for they spin a web of silken threads over the slippery scales, and thus secure the necessary foothold.

All the carnivorous forms so far mentioned, though they live in marshy places, are land plants, more or less perfectly adapted for the capture of insects and other small terrestrial animals. Some of them, however, have aquatic relatives, which are to be found floating in ditches and ponds, where they prey chiefly upon small crustaceans, such as water-fleas, mussel-shrimps, and copepods, though the larvæ of gnats and other insects are also among their victims, besides which they catch large numbers of the minute motile plants known as Diatoms. The floating habit conduces to success in this matter, for small crustaceans, &c., are

PITCHER-PLANTS (*Nepenthes*)

The plate represents a typical species (*Nepenthes destillatoria*) of a group of pitcher-plants which ranges from Madagascar through south and south-east Asia to the East Indies, Philippines, and tropical Australia. They live in damp forest-regions, at the side of pools, in the shallow water of which their seeds germinate. The leaves are modified in a remarkable manner for the purpose of catching and digesting flying-insects. The attached end of the leaf-stalk is broadened into a green expansion, followed by a tendril-like section, while the end of the stalk swells into a pitcher, which is overhung by a lid representing the blade of the leaf. Insects are attracted by the bright colours of the pitchers, and the nectar which is abundantly secreted around their openings and on the under side of their lids. But the inner side of the pitcher is as slippery as glass, and any insect that steps upon it quickly slides down into the contained fluid, which partly consists of a powerful digestive juice that reduces to solution the nutritious parts of the victim. The "peptonized insect-extract" thus prepared is absorbed by the lining of the pitcher, and constitutes a highly nutritious and stimulating food.

PITCHER-PLANTS (NEPENTHES DESTILLATORIA) AT THE EDGE OF A TROPICAL POOL

most abundant at or near the surface. Among these aquatic carnivores are certain small cousins (species of *Aldrovandia*) of Venus' Fly-Trap, which are specialized in much the same way. They are native to South and Central Europe, India, and Australia.

The Bladderworts (species of *Utricularia*, fig. 1067) are widely-distributed ditch-plants, closely related to the Butterworts, and

Fig. 1067.—Bladderworts (*Utricularia*)

represented in the British flora. They feed in part upon small aquatic organisms, and catch their prey in little bladder-like traps formed by modification of parts of the feathery leaves (fig. 1068). Each of these snares is not unlike a large water-flea in shape, and the resemblance is greatly increased by the presence of two branching bristles at the free end. Here, too, is placed the small opening into the bladder, guarded by a little transparent flap serving as a door, which opens inwards with the greatest ease, but prevents exit. Why little creatures should be attracted to

these traps is by no means clear, but minute crustaceans, &c., are fond of prying into holes and corners in search of food, while some of them may make use of the two branching bristles as a place of refuge from their enemies. And as the two bristles act as guides to the mouth of the trap the result is often tragic. Slimy hairs grow in this dangerous neighbourhood, which possibly have attractions to offer, while the little transparent door

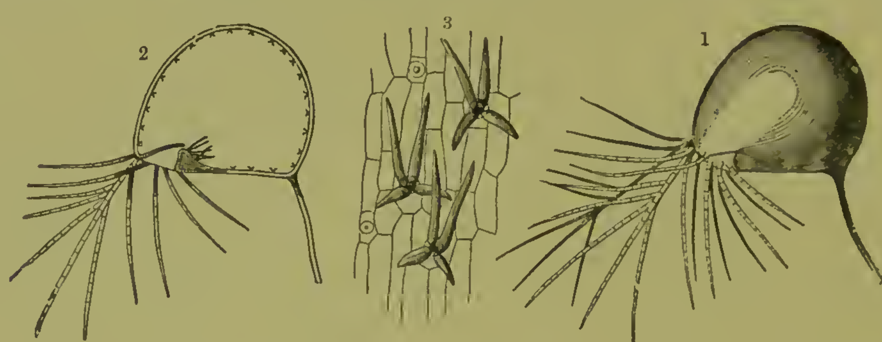


Fig. 1068.—Traps of Bladderwort (*Utricularia*), enlarged. 1, External view. 2, Longitudinal section. 3, Three absorptive branched hairs from interior. 1 and 2, × 4; 3, × 250.

must look like a spot of light, and perhaps acts as a lure. It is at any rate certain that victims are numerous, and their decomposed remains are absorbed by curious branched hairs which line the trap. The prey is apparently not digested as in Sundews and Butterworts.

The remaining topics dealt with in this chapter also more or less involve questions of nutrition, but are placed under separate headings for the sake of clearness.

ASSOCIATION OF PLANTS AND ANIMALS AS MESSMATES, MUTUALISTS, AND PARASITES

Commensalism.—Two associated organisms are known as Messmates or Commensals when they live together to the benefit of one or both; the union, however, not being of so intimate a nature as to be essential to the life of either. The term commensalism was coined to express such relations as existing between different animals, but there appears to be no reason why its meaning should not be extended to cover cases where two plants, or a plant and an animal, are similarly related. As an instance of the former we may take those tropical Orchids which regularly live upon trees, and are on that account said to be Epiphytes (Gk.

epi, upon; *phyton*, a plant). The advantage to the Orchids is obvious, though they do not absorb the sap of the plants upon which they live. These last, however, apparently derive no benefit from this one-sided arrangement.

There are numerous cases of commensalism between plants and animals in which the latter alone are benefited. In one of the Liverworts (*Frullania dilatata*, fig. 1069) which grow on tree-trunks there are little cup-like outgrowths on the under sides of the leaves, serving as the abodes of a species of Wheel-Animalcule (*Callidina symbiotica*). Marine plants often bear animals as messmates, which do them no harm. On a kind of brown sea-weed (*Fucus serratus*), for example, are frequently to be seen the little spiral tubes of a sort of Annelid (*Spirorbis*), which no doubt secures an increased supply of nutriment and dissolved oxygen by being moved about in the water when the tide is up. The Australian Sea-Horse (*Phyllopteryx eques*) also benefits by its association with the sea-weeds to which it bears a resemblance (see vol. ii, p. 296).

Fig. 1069.—Piece of a Liverwort (*Frullania dilatata*), showing cups in which a Rotifer (*Callidina symbiotica*) lives: enlarged. The small drawing is of one cup with its Rotifer (further enlarged).

Some instances are known of commensalism between a plant and an animal, in which both derive advantage from the association. Ant-plants illustrate such an arrangement (see p. 81), and so do the Sloths of South America, in which minute algæ live in the grooves of the fluted hairs. For these algæ are provided with a sheltered home, and at the same time give a greenish tint to the hairs, the Sloths being thereby rendered less conspicuous to their enemies.

Mutualism (Symbiosis).—Organisms living together as Mutualists are very intimately associated for mutual benefit. Mutualism between two plants is well illustrated by leguminous forms and the minute fungi which live in the tubercles on their roots. And every Lichen may be regarded as a joint-stock community, con-

sisting as it does of an alga and a fungus closely interwoven (fig. 1070).

Animals and plants may also be associated in an intimate way. It appears, for example, that the process of digestion in many animals is aided by certain bacteria which always live in their internal organs, as, *e.g.*, *Sarcina ventriculi* in the human stomach (fig. 1073). Bacteria of the sort are provided with a sheltered home and abundant food. Among the Animalcules (Protozoa) a well-known example is afforded by some of the Radiolaria, which always contain so-called "yellow cells", that are regarded as a kind of alga (fig. 1071). These cells are not only sheltered, but also absorb carbon dioxide, water, and salts from the fluids of the Radiolarian, which in its turn is provided with abundant free oxygen for breathing purposes, and possibly benefits in other ways. A somewhat similar association between some Sea-Anemones and minute algæ has been described. It is, however, possible that "yellow cells" and "algæ" are not plants at all, but specialized parts of the Ray-Animalcules and Sea-Anemones themselves.

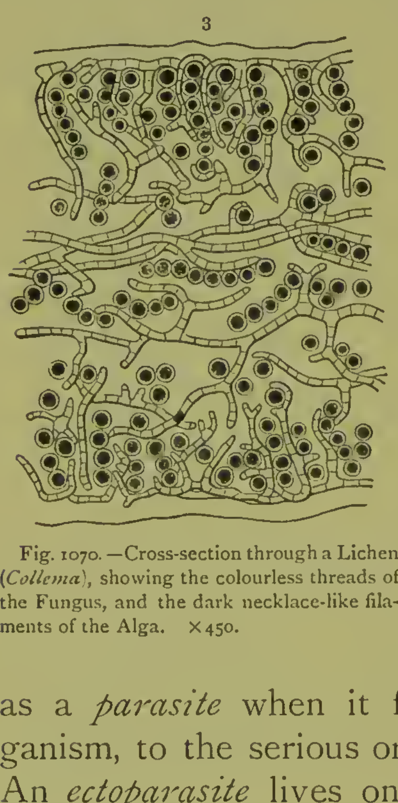


Fig. 1070.—Cross-section through a Lichen (*Collema*), showing the colourless threads of the Fungus, and the dark necklace-like filaments of the Alga. ×450.

Parasitism.—An organism is known as a *parasite* when it feeds upon the substance of another organism, to the serious or fatal detriment of this unwilling "host". An *ectoparasite* lives on the outside of its host; an *endoparasite* within it.

Many plants prey upon other plants in one way or the other. Clover-Dodder (*Cuscuta*), for example, is ectoparasitic upon Clover, while various fungi live as endoparasites within higher plants, *e.g.* Potato-Fungus (*Phytophthora infestans*) within the tissues of the Potato plant.

A large number of plants are known which are endoparasitic with regard to animals. In autumn many dead flies will be seen adhering to various objects by a sort of fluffy halo which surrounds them. These have been killed by the Fly-Mould (*Empusa muscæ*, fig. 1072), the delicate threads of which branch in

all directions through their tissues. Other fungi attack various caterpillars, *e.g.* the silk-worm disease known as "muscardine" is due to the Silk-worm Mould (a species of *Cordiceps*). A number

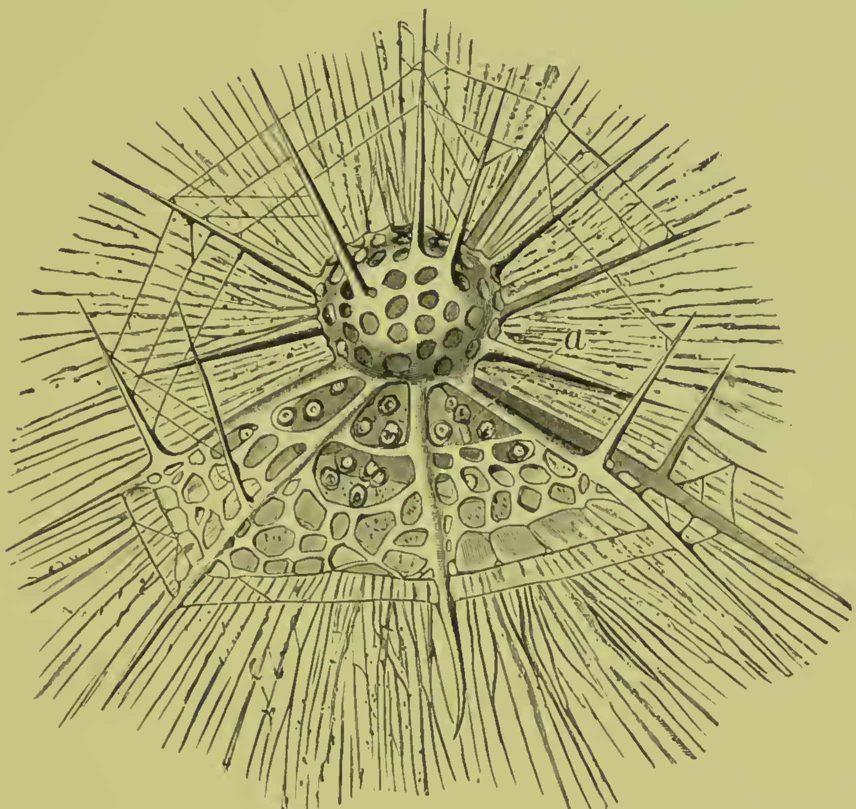


Fig. 1071.—A Ray-Animalcule (*Arachnocorys circumtexta*) with yellow cells (*a*), much enlarged

of skin-diseases, such as ringworm and "barbers' rash" are caused by parasitic plants of somewhat similar nature.

But the most notable, and at the same time the smallest, of the endoparasitic plants which attack animals are certain kinds of bacteria, which may literally swarm within the body, and give rise to a host of diseases, such as relapsing fever, typhoid, leprosy, Asiatic cholera, tuberculosis, diphtheria, anthrax, lock-jaw, and bubonic plague. Some idea of the small size of bacteria will be gathered from fig. 1073, or from statements that make some appeal to the imagination. It is said, for example, that 250,000,000 individuals of the species associated with bubonic plague could be crowded into the small space of a square inch. A number more than six times as great as the population of the United Kingdom at the last census.

Fig. 1072.—A House-Fly (*Musca domestica*) killed by Fly-Mould (*Empusa muscæ*), enlarged

In dealing with those animals that feed upon plants it is impossible to draw any clear line between vegetarians and parasites. We shall, however, be justified in applying the latter name to a number of small forms which live, generally for part of their lives only, within the tissues of plants, one consequence being the formation of certain abnormal growths. Some of these will be dealt with later on in connection with the subject of agricultural pests. The clubbing of turnip-roots ("finger-and-toe" or

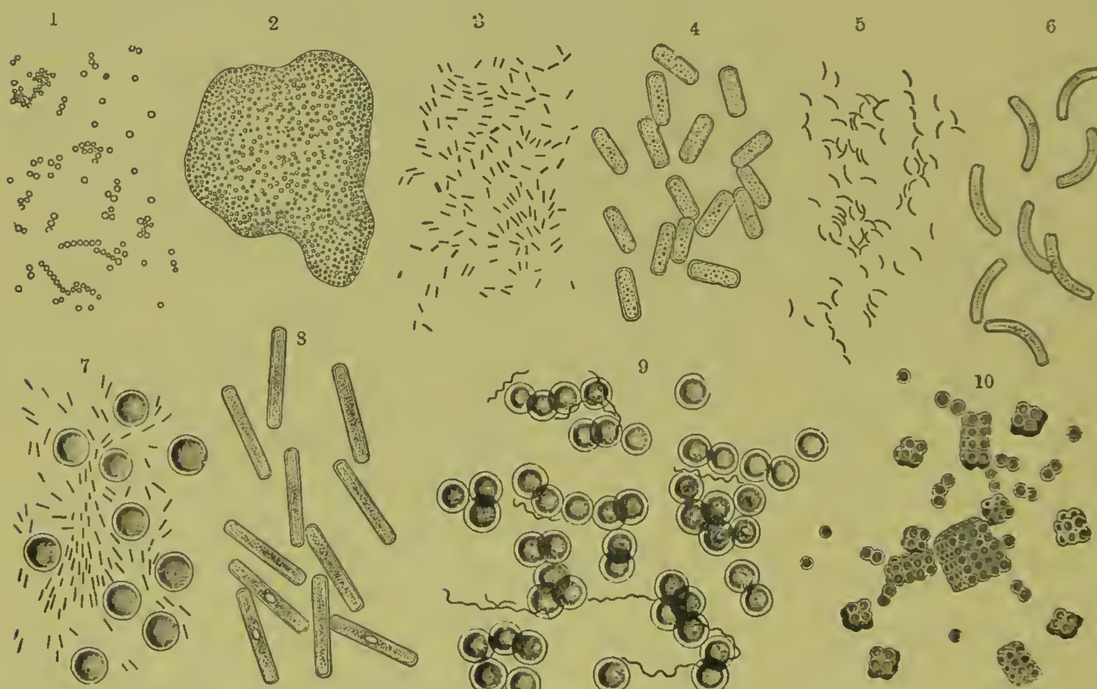


Fig. 1073.—Bacteria. 1, The "blood portent' (*Micrococcus prodigiosus*); 2, gelatinous stage of the same. 3, Bacteria which produce acetic acid (*Bacterium aceti*); 4, the same on larger scale. 5, Bacteria of Asiatic cholera (*Spirochæte choleræ asiaticæ*); 6, the same on larger scale. 7, Anthrax bacilli (*Bacillus anthracis*) with red blood-corpuscles; 8, the same on larger scale. 9, Bacteria of relapsing fever (*Spirochæte Obermeieri*) and red blood-corpuscles. 10, Symbiotic bacteria (*Sarcina ventriculi*) from human stomach. 1, 2, 3, 5, 7, and 9, × 300. 10, × 800. 4, 6, and 8, × 2000.

"anbury"), for example, is caused by one of the Fungus-Animals (*Plasmodiophora brassicæ*), which interferes with the nutrition of the plant, causing it to grow in an unusual way. And it not infrequently happens that cereals and some other cultivated forms are attacked by small Eel-Worms, the presence of which has a stunting or distorting effect.

Most persons have noticed the curious local outgrowths known as "galls" that are common upon some plants, and tempt comparison with the tumours and cancers of animals. They are due to the attacks of Gall-Flies, small forms belonging to the order of Membrane-winged Insects (*Hymenoptera*). The female gall-

fly punctures a bud, or leaf, or stem, by means of her sharp ovipositor, and lays an egg in the incision. The injury is trifling, but sets up irritation, probably caused by some secretion, and the result is an abnormal growth. Some of the different galls to be seen on oak-leaves are represented in fig. 1074. Other examples are furnished by the familiar "oak-apples", and the "bedeguars" of rose-bushes. A particular species of gall-fly always selects the same sort of plant, and attacks the same region, the resulting gall being of definite size, shape, and colour. A remarkable case is cited below (see p. 81), where the gall benefits the plant on which it is found.

Fig. 1074.—Various Insect-Galls on Leaf of Oak (*Quercus*)

Defences of Plants and Animals against One Another.—A good deal of space has already been devoted (vol. ii, p. 275) to the innumerable devices by which various animals are more or less protected in reference to carnivorous forms; but animals are also liable to be attacked by plants, especially by microscopic but deadly bacteria that induce many sorts of disease, particularly those of infectious or contagious nature. One important function of the white or colourless corpuscles which live in lymph or blood appears to be to repel the attacks of dangerous "germs" of the sort (see vol. iii, p. 4). The principle involved in vaccination or inoculation is related to the fact that animals which have been purposely subjected to the influence of a disease-germ that has been weakened by artificial methods (or to the action of a related but less dangerous kind of germ), are thereby rendered able to resist more or less successfully the onslaughts of the same sort of germ in its more virulent form. Another important application of preventive (and curative) medicine has resulted from the discovery that some animals are protected from particular disease-germs by means of complex substances (defensive proteids or anti-toxins) contained in their blood. The best-known example is afforded by diphtheria, which can be warded off, or combated if con-

tracted, by means of an anti-toxin extracted from the blood of the horse.

Turning to the other side of the question, we find that numerous plants are protected by various means against vegetarian animals. Many species, for example, more or less successfully ward off the attacks of browsing forms by mechanical devices. Of this nature are the thorns, spines, prickles, and stinging hairs with which painful experience has made most of us more or less familiar. Good illustrative cases are such common forms as gorse, blackthorn, holly, thistle, and stinging-nettle. This is not, however, the only use of sharp-pointed outgrowths, for not a few forms, *e.g.* the bramble, are "hook-climbers". It is particularly noticeable that ripening fruits are often mechanically guarded, the prickly husks of horse-chestnut being a case in point.

Fig. 1075.—Cell from Leaf of Virginia Creeper (*Ampelopsis*), containing a bundle of needle-crystals (raphides) of oxalate of lime; highly magnified

Quite a number of herbaceous plants contain in their soft tissues bundles of exceedingly sharp needle-like crystals (raphides, fig. 1075) which protect them against the ravages of slugs and snails, as experiment has shown. Many such crystals are to be found, for example, in the leaf-stalks of the Arum-"Lily" (*Richardia Æthiopica*).

Many plants are protected by chemical means, *i.e.* by the formation within their tissues of substances which are poisonous or nauseous, or otherwise detrimental to the well-being of would-be consumers. Forms such as Foxglove, Aconite, Monkshood, Hemlock, and Yew no doubt ward off to a great extent the attacks of browsing animals in this way. Fruits and seeds are often thus protected, and may be either simply nauseous (especially when unripe) or else contain active poisons, as in the case of the seeds of Laburnum and *Strychnos nux-vomica*. The attacks of both large and small animals are checked in many cases by means of a sticky fluid known as *latex*, which flows from an injured part, and when fresh has a milky appearance. Common examples among British plants are the Spurges (*Euphorbia*), Poppy, Greater Celandine, and Dandelion. This secretion hardens when dry, and forms a protective coat over the wound. Some tropical trees produce a kind of latex which, in the solidified condition, is known to us as india-rubber. It is almost

certainly to be regarded as a means of defence against wood-boring insects, especially beetles. The many varieties of resin and gum are also of protective nature.

We have already had occasion to note (vol. ii, p. 301) that quite a number of animals advertise their disagreeable properties by conspicuous colours or by other means. Such warning coloration also appears to be present in certain plants, as, for instance, in some of the poisonous toad-stools, which are of glaring and repulsive appearance. And here also it would seem that, as among animals, cases of Mimicry are to be found, for some harmless toad-stools closely resemble their poisonous brethren, and thus gain some amount of protection. The highly desirable *Boletus edulis*, for example, is very liable to be mistaken for its virulently poisonous cousin (*B. Satanas*).

Fig. 1076.—Acacia (*A. sphærocephala*), possessing hollow thorns in which ants finds shelter, and pear-shaped food-bodies on tips of leaflets.

Another set of plants contain aromatic or fragrant essential oils which, though pleasant enough to our own sense of smell, act as deterrents to many animals. Such are sage, mint, lavender, and many spice-producing forms.

There is still another means of defence, and one which is more interesting from the zoological standpoint than those so far described. Certain forms are known which may appropriately be termed ant-loving (*myrmecophilous*), because they maintain a "police-force" of ants, by which they are protected from leaf-cutting insects and other unwelcome visitors. The services of these hirelings are secured by means of material benefits of substantial character. A well-known case is that of a sort of Acacia (*Acacia sphærocephala*, fig. 1076), which bears little pear-shaped "food-bodies" to appease the appetites of its retainers, and also hollow thorns which furnish them with shelter. Another curious instance is afforded by a kind of Oak (*Quercus pubescens*) in which a gall-

fly (*Cynips argentea*) lays her eggs. The abnormal growths or "galls" which result from this process secrete nectar that serves to attract ants, and thus a body-guard is secured by which the attacks of caterpillars and snails are repelled. The following account is given by Kerner (in *The Natural History of Plants*) of the way in which ants protect the flower-heads (capitula) of certain Composites:—"A similar state of affairs is met with on

Fig. 1077.—A Saw-Wort (*Serratula lycopifolia*) defended by Ants (*Formica exsecta*) against the attacks of a Beetle (*Oxythyrea funesta*)

the capitula of several Composites indigenous to South-eastern Europe, *e.g. Centaurea alpina* and *Ruthenica, Jurinea mollis*, and *Serratula lycopifolia*, the last of which is here figured [fig. 1077]. The young heads of these Composites are particularly liable to the attacks of voracious beetles, especially of *Oxythyrea funesta*, which bites big holes in them, destroying crowded flower-buds and involucral scales [*i.e.* the overlapping scales which surround the head] without the least difficulty. To meet this danger a garrison of warlike ants is employed. Honey is secreted from

big stomata [*i.e.* pores in the epidermis] on the overlapping scales of the still-closed heads in such quantities that one can see a drop of it on every scale in the early morning, whilst later in the day, as the water evaporates, little masses, or even crystals, of sugar are to be found. This sugar, either in its liquid or solid form, is very palatable to the ants, which habitually resort to these heads during the period of its secretion. And to preserve it for themselves they resent any invasion from outside. If one of the aforementioned beetles appears they assume a menacing attitude. They hold on to the involucral scales with their last pair of legs and present their fore-legs, abdomen, and powerful jaws to the enemy, as shown in the figure. Thus they remain till the beetle withdraws, if necessary hastening its retreat by squirting formic acid in its direction. Then they quietly begin to feed on the honey again."

Much has yet to be learnt about the relations between British plants and insects in the present connection, and no undoubted case of ant-guards has so far been described. Some of our native trees, however, harbour mites that appear to discharge defensive duties. Scott Elliot (in *Nature Studies*) thus speaks of them:—"Almost any common tree, such as the Lime, Ash, Elm, or Horse-Chestnut, will show on the lower side of the leaves little hairy patches which occupy the forks of the veins. If these are examined in summer with a strong magnifying glass, and stirred up with a pin, very small active . . . mites will be found. They run about quickly, and once seen, can be observed with ease, whenever looked for. The hairy grottoes which they inhabit are often rather neatly formed; but they are difficult to describe. As a rule the colour of the mite is that of the hairs amongst which it lives. These mites come forth at night, and appear to live upon bacteria and upon the spores of fungi, lichens, or algæ. But here again it is not possible to give as exact details as would be desirable." The arrangement described is of special interest, as it appears to be a case of animals defending a plant against other plants lower in the scale.

THE POLLINATION OF FLOWERS BY ANIMALS.—Of all the numerous kinds of relation between plants and animals none has attracted more attention than the one now to be briefly described. So much is this the case that, though of absorbing interest, it is almost in danger of becoming hackneyed. But

its study has done much towards revolutionizing the old cut-and-dried method of studying botany, and has caused so many persons to pay some attention to the world of life, that no excuse is made for presenting here a few facts which will be familiar to most readers, especially as the scheme of this work would be incomplete without them.

To understand the meaning of the word "pollination" it is first of all necessary to say something about the structure of flowers. These are concerned with the production of seeds, in each of which is to be found an embryo or plantlet in a dormant state, capable, under favourable conditions, of growing into a new plant. We have elsewhere seen (see vol. iii, p. 335) that in animals the first stage in propagation by means of eggs consists in the fertilization of an egg-cell or ovum by fusion with it of a smaller cell or sperm, the fertilized egg-cell afterwards developing into an embryo. The embryo in a seed has also arisen from an egg-cell, which has been fertilized by material formed in the same flower (self-fertilization) or in some other flower (cross-fertilization). The result in the latter case is better than in the former, since cross-fertilized egg-cells develop into more vigorous embryos, and many floral arrangements are to be explained as means by which cross-fertilization is brought about.

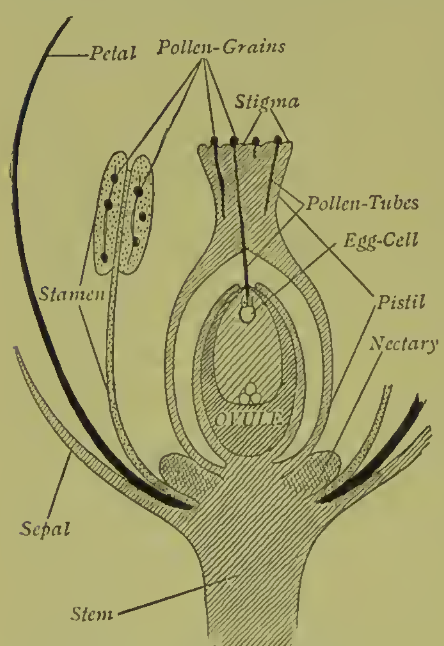


Fig. 1078.—Diagrammatic Section through a Simple Flower

Examination of a typical flower (fig. 1078) shows that it is made up of four sets of structures, all of which are specialized leaves. Beginning at the outside they are as follows:—(1) *Calyx*, consisting of a circlet of *sepals*, which may be green (as in a Buttercup), or brightly coloured (as in a Tulip); (2) *Corolla*, made up of *petals*, which are commonly conspicuous; (3) Thread-like *Stamens*, within the thickened ends (*anthers*) of which is formed the powdery substance, *pollen*, from which the fertilizing living substance is derived; (4) *Pistil*, consisting of one or more *Carpels*, which in the latter case may be either separate or fused together (a single carpel is shown in the figure). The carpels contain a varying

number of small bodies known as *Ovules*, destined to become seeds, and the most important part of an ovule is a minute *egg-cell* or *ovum*. On the top of the pistil is a rough and sticky surface, the *Stigma*.

Pollination is a necessary preliminary to fertilization, and consists of the transfer of ripe pollen-grains to the stigma. Supposing this to have been effected, a thread-like *pollen-tube* grows from each grain into the cavity of the carpel until it reaches that part of the ovule where the egg-cell is located. A nucleus-containing fragment of protoplasm (equivalent to a sperm) from the tip of the tube is then transferred to this cell, with which it fuses. The egg-cell, thus fertilized, develops into an embryo, and the rest of the ovule undergoes certain modifications, the total product being a seed.

A stigma may be pollinated by grains developed in the stamens of its own flower (self-pollination), or by grains derived from other flowers (cross-pollination). The latter, since it is followed by cross-fertilization, is the more desirable event, and the actual transfer of pollen from flower to flower is effected by water, wind, or animals, according to the nature of the arrangements which have been evolved. We are here only concerned with animal-pollinated (zoophilous) flowers, and in the large majority of these the agents are insects. Many of the characters of insect-pollinated (entomophilous) flowers have been evolved with reference to the attraction and reception of suitable guests. It was at one time the general belief that the varied odours and hues of flowers came into existence simply and solely for the delectation of mankind; as a matter of fact their significance is utilitarian, and has reference to the needs of plants themselves. For scent and colour are the means employed to attract insects (and sometimes other animals) capable of doing the work of cross-pollination. It is fortunate that the odours generally commend themselves to us, but this is not always so, for certain flowers (*e.g.* some Arums) smell like carrion, the object being to attract those flies which revel in putridity. As to colour there is of course a great variety, and some tints appeal to special visitors. Typical "bee flowers", for example, are commonly reddish-purple, purple, or blue. Other forms depend upon dusk-loving insects, especially moths, for their cross-pollination, and these are white or pale in hue, which gives them the best chance of being seen (fig. 1079).

Such flowers open in the evening, and are then most fragrant. Conspicuousness is often increased by numerous flowers being associated together.

For the entertainment of their insect-guests flowers may provide sweet sap, or produce a great excess of pollen, a highly nutritious substance, or secrete nectar. In highly-specialized forms at least the last sort of food is generally the most important, and is usually produced deep down in the recesses of the flower, often in long spur-like tubes, where it is only accessible to long-tongued insects, such as bees and butterflies.

Fig. 1079.—The Nottingham Catch-Fly (*Silene nutans*) by Night, a flower being visited by a moth (*Dianthœcia albimacula*); the remains of dead creeping insects are seen adhering to the viscid stem

Flowers not only attract guests and provide refreshment, but their whole structure is often modified, it may be in a very complex way, to secure the benefits of cross-pollination, *i.e.* to ensure that pollen which is brought is deposited on the stigma by arriving guests, and make certain that departing guests take with them a fresh supply of the same material.

In many cases the adaptations existing between flower and insect are so perfect as to leave no room for doubt that each has influenced the evolution of the other. Some of the adjustments that have come into existence will best be understood by reference to concrete examples, the first two of which will be taken from the remarkable Orchis Family, the members of this being notable for the great variety of arrangements which they display in relation to insect-pollination. In one large and handsome species (*Phalænopsis Schilleriana*, fig. 1080) the attraction of colour is provided by five spreading leaves, equivalent to sepals and petals, of which the most remarkable (the *labellum*) is one which hangs down from the centre of the flower. It begins in a narrow stalk, but soon

broadens into three lobes, of which one curves up on each side, while the third takes a downward course and divides at its end into a couple of curved projections. Just at the place where the stalk expands into lobes a small double projection arises from its upper side, and this serves as a footstool for flies, which are here

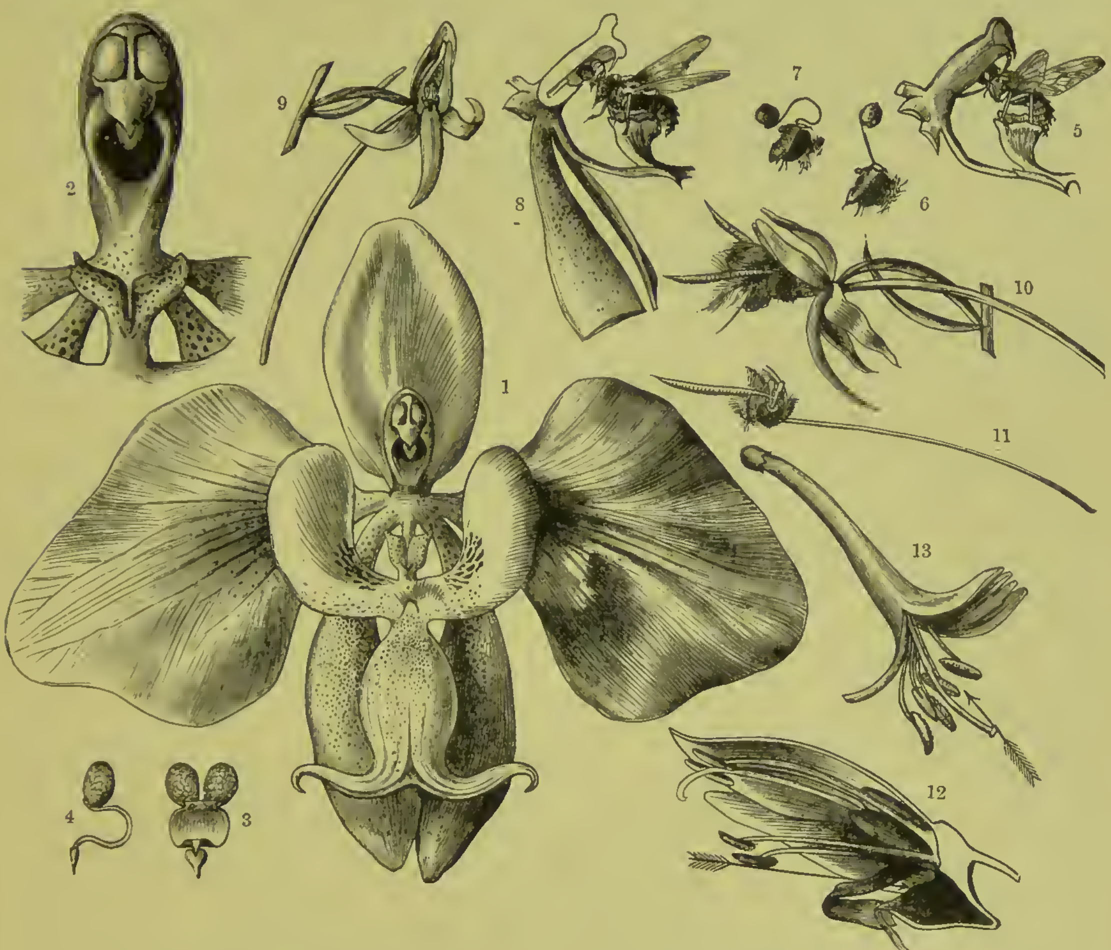


Fig. 1080.—Cross-Pollinated Flowers. 1, Front view of a fly-pollinated orchid (*Phalænopsis Schilleriana*); 2, column of same, showing bilobed footstool; 3, pollen-masses of same attached to sticky heart-shaped gland; 4, side view of pollen-masses; 5, side view showing a fly on the footstool; 6, head of the fly with attached pollen-masses; 7, the same after the pollen-masses have bent forwards; 8 (in vertical section), shows a fly introducing pollen-masses to another flower. 9, Flower of the moth-pollinated Lesser Butterfly Orchis (*Habenaria bifolia*); 10, the same, with head of a moth (*Sphinx pinastri*) probing the long spur with its proboscis; 11, head and extended proboscis of the moth. 12, Side view of a bird-pollinated flower (*Melianthus major*) with outer part removed, four stamens and the long curved style are seen; the arrow indicates the way to the honey-containing spur. 13, Flower of a moth-pollinated honeysuckle (*Lonicera Etrusca*) with long honey-containing tube; the arrow shows how to reach this the rounded stigma and stamens must be successively touched. 2, 3, 4, 6, and 7, slightly enlarged; the other figures natural size.

the invited guests. In the middle of the flower, just behind the footstool, may be seen a short projecting "column", the rounded top of which is constituted by a short stamen, immediately beneath this being a deep hollow, the stigma. The pollen is aggregated into two masses (*pollinia*), attached to a little curved plate, which

passes below into a heart-shaped sticky knob (*rostellum*) that projects into the cavity of the stigma. If now a fly alights on the footstool and begins to lick up the nectar from the stigma, its head will come into contact with the rostellum, and on leaving the flower it will carry away the pollinia, which very quickly bend forwards. When the fly visits another flower and thrusts its head into the stigma, the sticky surface of this will catch and retain the pollinia, another pair of which will become attached to the head of the insect, to be carried on in their turn to another blossom.

The Lesser Butterfly Orchis (*Habenaria bifolia*, fig. 1080) is a much smaller form native to Britain, and cross-pollinated by Hawk-Moths. A number of whitish very fragrant flowers are borne upon a long upright stalk, and there is here no platform for the arriving guests, as these sip nectar without having to alight. The nectar is contained in a slender spur, the length of which corresponds to that of the unrolled proboscis of the moth. As before, the departing guest carries away the two pollinia, which then bend downwards, and converge together into the exact position necessary to ensure their striking the stigma of the next flower visited. In regard to these movements, and the somewhat different ones made by the pollinia of other species, Darwin remarks (in *Fertilization of Orchids*):—"A poet might imagine that whilst the pollinia were borne through the air from flower to flower, adhering to an insect's body, they voluntarily and eagerly placed themselves in that exact position, in which alone they could hope to gain their wish and perpetuate their race". To this same book of Darwin's are referred those readers who desire further particulars regarding Orchids in the present connection.

The different species of Honeysuckle (*Lonicera*, fig. 1080) are also "moth-flowers", and exhibit three of the leading features just detailed for the Butterfly Orchis, *i.e.* absence of an alighting platform, pale colour, and marked fragrance. But, as in most flowers except Orchids, the pollen is dust-like, and not aggregated into pollinia.

Insects are not the only animals by which cross-pollination is brought about, for in some instances this work appears to be discharged by Snails and Slugs, Birds, or Mammals. In our two native species of Golden Saxifrage (*Chrysosplenium*), snails and slugs are said to be the agents. These plants live in damp places, and possess groups of small greenish-yellow flowers, over which

the slimy visitors crawl, transferring the pollen from one blossom to another.

The Humming-Birds of America, and the little Sun-Birds of Africa, which resemble them in appearance, suck nectar while on the wing from certain flowers. Regarding bird-pollinated forms, Scott-Elliot, who made a special study of the subject in South Africa, speaks as follows (in *Nature Studies*):—"Many tropical flowers, such as the Banana, or the beautiful *Lobelia cardinalis*, are visited by the Sun-Birds and Humming-Birds. A great proportion of these flowers have a scarlet colour, and a curved tube which exactly fits the head and beak of the bird. Others, which are visited by these beautiful and lively creatures, have the flowers massed together in large cup-shaped heads, such as the *Proteas*, or Sugarbush of South Africa. The bird stands on the edge of this cup and plunges its beak into the mass of honey flowers which fills it. There are no bird flowers in the British Flora, at least so far as the writer's knowledge goes; but sparrows can be seen to dip their beaks into the heads of the Ragwort, after insects, and it is very likely that the flower-haunting habits of the Sun-Birds began in this way." One of the bird-pollinated African forms (*Melianthus major*) is represented in fig. 1080.

Few observations have been made upon cross-pollination by mammals, but some tropical Bats are supposed to further the transference of pollen, and Kerner suggests that the same kind office is discharged by Kangaroos for Dryandra bushes. The flowers in the latter case are at a suitable height above the ground, and are arranged round the edge of a sort of cup, into which a fluid resembling sour milk trickles down from them. It is not improbable that the little Long-Snouted Phalanger (*Tarsipes rostratus*, see vol. ii, p. 181) transports the pollen of the flowers which it constantly visits.

Prevention of Self-Pollination.—The various arrangements related to cross-pollination have been so evolved that they also, at least for some time, prevent self-pollination. It may be that a particular flower contains stamens only or a pistil only, and these distinct staminate and pistillate flowers may either be on the same plant (*e.g.* Spurges,—*Euphorbia*) or on different plants (*e.g.* Willows,—*Salix*). And even where stamens and pistil are present in the same flower the pollen is commonly produced before the stigma is mature, or, more rarely, the stigma is first ready. Of other

kinds of arrangement we may take the common wild Monkey-Musk (*Mimulus luteus*, fig. 1081) as an interesting example. An insect visiting this flower first touches the bilobed stigma, which receives any pollen that the visitor may bring. But the stigma is very sensitive to contact, and immediately closes, almost like a book, remaining in this state for some time. Hence it does not receive from its own flower any of the pollen with which the departing guest has been loaded.

It ought, however, to be stated that some flowers are regularly self-pollinated, while others exemplify a number of most ingenious devices for effecting this as a last resort. The whole structure of

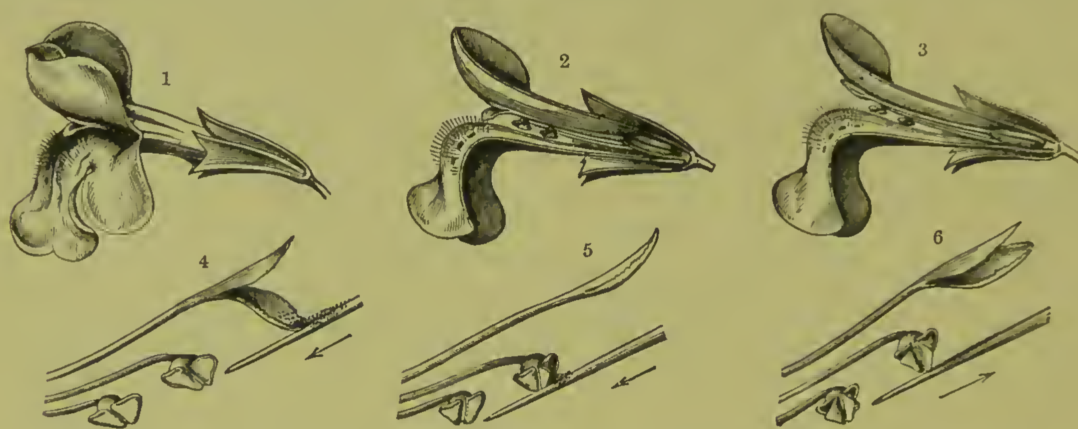


Fig. 1081.—Pollination of Monkey Musk (*Mimulus luteus*). 1, External view of flower; 2, same in longitudinal section, with open stigma; 3, ditto with closed stigma. 4, Pollen is deposited on the lower lip of the stigma by a proboscis passing in the direction of the arrow; 5, the stigma has closed, and the proboscis passing on opens the closed anthers and becomes covered with pollen; 6, proboscis being withdrawn in direction of arrow, but does not deposit pollen on the stigma as this is closed. 1, 2, and 3, natural size; 4, 5, and 6, somewhat enlarged.

a Foxglove flower, for example, is wonderfully adapted to cross-pollination by humble-bees, but after a time the purple corolla falls off, and in so doing drags the stamens attached to it over the stigma, so that this is self-pollinated, and if it has not already received foreign pollen, the egg-cells will be self-fertilized. Full details of this sort of arrangement will be found in Kerner and other botanical works, but would be out of place here. It is perhaps desirable to add that some authorities believe the importance of cross-pollination to have been somewhat exaggerated.

Defences of Flowers against Unbidden Guests.—The animals which are most serviceable as agents of cross-pollination are those capable of carrying pollen from one plant to another, though interchange between flowers on the same plant is beneficial to a lesser degree, and is often the chief kind of crossing which takes place in cases where a considerable number of small flowers

are crowded together. The most specialized plants lay themselves out, so to speak, to attract insects with well-marked powers of flight, or in some cases birds, and it may be mammals. These are the "bidden guests". But there are also "unbidden guests" with a liking for nectar, especially wingless insects, such as ants. In many cases these undesirable visitors simply rob the flowers without conferring any benefit. There are also numerous snails and slugs which eat up flowers altogether if they get the chance. It is for all reasons desirable that these useless and dangerous visitors should be kept away. Ogle, in the preface to his translation of a work by Kerner (*Unbidden Guests*), thus presents the matter:—
"Now Nature, who at first sight often appears a prodigal, is always found, on closer examination, to be the most rigid of economists. If no insects are to be allured, she gives . . . no nectar; she cuts off the bright petals and suppresses the attractive odours. Nor even when a bait is wanted will she give it one minute sooner than is necessary. The brilliancy, the scent, and the nectar are only furnished when the flower is ready for its guests and requires their presence; just as a thrifty housewife lights her candles when the first guest is at the door. The mature bud is furnished with no such attractions. Still more, even when the flower is mature, when its pollen is ready for transference or its stigma for pollination, when all the allurements are consequently displayed and insects invited to the feast, she still shows her economy. Guests might come who were not of sufficient importance, and the banquet be wasted on them; for it is only when insects have a certain shape, size, or weight that she requires their visits, and can use them profitably for her purposes. She requires, moreover, that they should make their entrance by the main portal, which she has specially adapted to suit their and her requirements. All insignificant and unremunerative visitors, all such, moreover, as would creep in by the back entrance, must be kept out. . . ."

It will be convenient to first describe the chief ways by which wingless insects are kept away from the flowers. One rather curious device is found in some of the Balsams, *e.g.* in a species native to the Himalayan region (*Impatiens tricornis*) which has been carefully studied. Here, as in many other plants, there are little expansions (stipules) at the bases of the leaves, where they join the stem. Of each pair of stipules one is transformed into a nectar-secreting gland (nectary) in the form of a thick curved plate,

so situated that insects creeping up the stem are sure to find it. As soon as the Balsam begins to open its flowers nectar is abundantly secreted by these nectaries, and being both abundant and more accessible than that in the flowers, unwelcome guests are diverted from these. Regarding this sweet fluid and its use Kerner makes the following remarks:—"The honey-loving ants lick it up eagerly, and are content not to stray farther upwards. Actual observation shows that the flowers of *Impatiens tricornis* are free from ants, whilst these stipular nectaries are much frequented by them. Their presence in the flowers is very undesirable, since they could readily get at the honey there without touching the pollen or stigma. And more than this, they would not only pilfer the honey, but they would also drive away those winged insects for which the honey is prepared—the welcome guests that pollinate the flowers. We are justified on the facts in regarding this diversion of the unbidden guests as an indirect protection of the floral honey."

Fig. 1082.—A Teasel (*Dipsacus laciniatus*), showing water-cups formed by fusion of bases of leaves

Insects are not infrequently prevented from reaching the flowers by means of a watery barrier. This is obviously so in the case of water-lilies and other aquatic plants, and may also be observed in some land forms. In Teasels, for example, the leaves are arranged in pairs, the bases of each pair being united together to form a sort of cup, in which water collects, so as completely to surround the stem (fig. 1082).

Slippery surfaces are often present, on which creeping insects can find no foothold. There is sometimes a smooth coating of wax, as in certain Willows, where the catkin-bearing twigs are thus protected. Another interesting case is that of the Snowdrop

(*Galanthus nivalis*, fig. 1083). Here the smooth flower-stalk is bent over, so that the flower hangs down, and a creeping insect trying to reach it is almost certain to fall when it reaches the sharp bend. The nectar secreted in the green grooves of the petals is intended for flying insects. If one of these approaches from below it will first touch the stigma, effecting pollination if it has previously visited another snowdrop. And in getting the nectar it is sure to jolt the stamens, causing a shower of pollen to fall on its back, ready for transfer to other blossoms.

Fig. 1083.—Flower of Snowdrop (*Galanthus nivalis*)

A more drastic method of dealing with creeping insects is found in many plants which exude a sticky fluid, especially in the neighbourhood of the flowers, or actually upon them. Sometimes this is of the nature of latex, as in the Lettuce (*Lactuca sativa*), where the flower-heads are surrounded by overlapping scales from which the milky secretion readily escapes, quickly coagulating into a sticky mass that catches and smothers ants and the like. The flower-stalks of Catch-Flies (see p. 86) and various other forms are covered by a glutinous layer, to which the bodies of trespassers are often found adhering. But more commonly the secretion is poured out by variously-situated glandular hairs. In Plumbago, for instance (fig. 1084), they are borne on the calyx. It would appear that in some instances the captured insects are used as food, after the fashion of the carnivorous plants already described (see p. 68).

Fig. 1084.—Flower of *Plumbago Europæa* (enlarged), showing glandular hairs on the calyx

So far we have dealt with the exclusion of wingless insects, but in the case of large flowers evolved in relation to bees, wasps, butterflies, &c., small-winged insects are equally undesirable visitors, since they steal nectar without effecting cross-pollination. Such forms are altogether excluded, or else made effective by arrangements in the flowers, which Kerner thus describes in general terms (in *The Natural History of Plants*):—"Peculiar folds and cushions, walls and gratings,

brushes and thickets of hairs are present, guarding the entrance and rendering access difficult, whilst still allowing it. Large and powerful animals find these obstacles no hindrance, and readily brush them aside; small ones, however, cannot do this, but have to climb over or circumvent the obstacles. And in many cases this enforced divergence by small insects from the direct path brings about the desired result. For, in circumventing these folds and barricades and hairs, they are unconsciously led past the anthers and stigmas, contact with which is unavoidable. Thus, what would otherwise be useless visitants become welcome guests. They are conducted indirectly to the honey by these curious structures, which may, in a sense, be termed 'path-finders'." Cursory examination of such flowers as Foxglove or Pansy will show the presence of barricades of the kind mentioned (see also fig. 1085). Path-finders for the guidance of invited guests are often present in the form of conspicuous colour-streaks, which converge towards the source of nectar. Pansy, Azalea, and Pelargonium are particularly good examples of this.

Fig. 1085.—Section through Flower of a Honeysuckle (*Lonicera alpigena*), showing protective tufts of hair; enlarged

The defences and other arrangements which have been evolved in various connections by plants and animals are never completely successful, and with changed surroundings are apt to fail. This applies not only to "mice and men", but also to flowers. Kerner states, for example, that the flowers of some 300 European plants are systematically robbed by humble-bees, which take a short cut to the nectar by biting through the calyx or corolla. The result may be disastrous, for in some of these plants but few seeds are produced, so that they are becoming rare, and in course of time will probably die out altogether. Certain Alpine Catch-Flies (*Silene Pumilio* and *S. Elizabethæ*) are in this evil case. Kerner suggests that such plants date back to a time when there were no, or but few, humble-bees in the region where they now grow, and that they have since failed to evolve means of defence against the new kind of attack.

Wingless enemies of soft-bodied character, especially snails

and slugs, are not kept off by smooth surfaces or sticky secretions. But such creatures are easily baffled by prickles, bristles, thorns, and other sharp structures, and these are often found in the neighbourhood of the flowers.

Dispersal of Plants by Animals.—Since the large majority of plants are fixed, means of dispersal are clearly a necessity, as otherwise they would have to struggle for existence with their own offspring. And it is only when numerous individuals of a species are placed in favourable surroundings that the species has any chance of escaping extinction. It is not therefore surprising to find that there are almost innumerable ways by which dispersal is effected. Sometimes the plant itself is the agent, sending out creeping stems above or below ground, or ejecting its fruits, seeds, or spores to a distance by explosive or elastic mechanisms. Currents of air and water are also of great importance in this connection. But we are here only concerned with the chief ways in which animals are pressed into the service of plants for this purpose, or it may be render assistance of more casual kind.

Many of the small plants which float in ponds, such as Duckweeds (*Lemna*) and various algæ, must often cling to the legs of water-birds, and get carried bodily from place to place. And it is noticeable that the buds of somewhat larger aquatic plants, such as Frog-bit and Bladderwort (*Hydrocharis* and *Utricularia*), possess a slimy covering by means of which they readily adhere to the plumage of such birds. Among marine plants a curious means of transit is exemplified by various sea-weeds which certain crabs plant on their backs to make themselves inconspicuous (see vol. ii, p. 287). On the decease of such a crab his little "garden" goes on growing, unless perchance he has been swallowed whole by some predaceous form.

A good many land-plants propagate by means of "offshoots", *i.e.* specialized branches, &c., which grow into new individuals, and cases have been noted where animals assist in the dispersal of such offshoots. Some of the rounded Mexican Cacti (species of *Mammillaria*), for example, produce little spherical shoots studded with barbed bristles, and which are very readily detached from the parent plant. They readily cling to the coats of various mammals and may thus be carried for a considerable distance.

Dispersal of Seeds and Fruits by Animals.—As already explained (p. 85), a seed may be regarded as a matured ovule,

in which is contained a dormant plantlet, that has resulted from the fertilization of an egg-cell. The fertilizing process stimulates the growth of various parts external to the ovules, leading to the production of what may broadly be called a "fruit", which for our present purpose may be considered as a seed-carrier. A cherry or plum, for example, is a fruit, within which is a single seed—the "stone". A long account of the different kinds of fruit would be out of place here, but it may be well to add that many are hard and dry, *e.g.* hazel-nuts (of which the "kernels" are the seeds), poppy-"heads", and the so-called "seeds" of Sunflower or Carrot.

The dispersal of seeds in many plants results from the fact that a considerable number of animals are fruit-eaters. And in such cases the seeds being protected by hard coats often escape digestion. It would appear that the attractive colours and palatable qualities of numerous fruits have been evolved with direct reference to this. While still unripe such fruits are inconspicuous and more or less nauseous, but become extremely conspicuous by the time they are ready for consumption, thus advertising their desirable properties as articles of diet. Though monkeys and other fruit-eating mammals no doubt largely assist in plant dispersal, birds seem to play a more important part in the matter. Kerner made a large number of experiments which tend to prove this. He found, for example, that the hard-coated seeds of stone-fruits and berries passed quite uninjured through the bodies of ravens and jackdaws; also that the blackbird, song-thrush, rock-thrush, and robin, which eagerly devour fleshy fruits, throw up the seeds if these are large, as in Barberry and Privet. The fate of small seeds swallowed by the last four birds is thus described by him (in *The Natural History of Plants*):—"Of the fruits and seeds which passed through the intestine of one or other of these birds, 75 per cent germinated in the case of the blackbird, 85 per cent in the case of the thrush, 88 per cent in the case of the rock-thrush, and 80 per cent in the case of the robin. . . . From these experiments it is evident that the dispersal of edible fruits through the agency of thrushes and blackbirds is not, as was formerly supposed, an exceptional phenomenon obtaining in the mistletoe only, but one that may take place in the case of many other plants, and other observations prove that, as a matter of fact, it does take place."

Some animals store up seeds and fruit for future use, and as for various reasons many of these escape being eaten, the storing habit undoubtedly promotes dispersal. Squirrels, jays, and many ants may be cited in illustration. The case of ants is peculiarly interesting. According to Kerner's observations the seeds which prove attractive to these little creatures are those which, although smooth, possess a little rough outgrowth technically known as a "caruncle", as in Violet, Greater Celandine, Snowdrop, Periwinkle, and some Spurges. It is only this caruncle which is eaten, the rest of the seed being left untouched, and capable of germination.

Besides the seeds and fruits which specially appeal to the appetites of animals, there are many others which become attached to their bodies, and are thus effectively dispersed. This may take place without any special adaptations to clinging, as in the case of the floating seeds of many aquatic plants, which adhere to the plumage of birds, or where moist earth containing seeds sticks to the feet of birds or other animals.

Fig. 1086.— Fruit of *Linnæa borealis* (×5) studded with glandular hairs

There are, however, a large number of fruits and seeds which are either sticky or else studded with hooks, their chances of transport by animals being thus greatly increased. Stickiness results in many cases from exposure to moisture, as in the seeds of Meadow Saffron (*Colchicum*) which have often been observed adhering to the feet of sheep, cattle, and horses. A somewhat more specialized case is afforded by fruits which owe their viscidity to the presence of glandular outgrowths, *e.g.* *Linnæa borealis* (fig. 1086).

A firmer means of attachment is found in seeds and fruits provided with hooks, and its efficiency would seem to be proved by the fact that about ten per cent of Flowering Plants are provided with such arrangements. They have apparently been evolved, at least in many cases, in relation to the hairy coats of Mammals, for they are particularly characteristic of plants of low stature, with which such animals are likely to come into contact. Many examples are found among the members of our native flora, as everyone who knows the country must have observed. The little globular fruits of the Goosegrass or Cleavers (*Galium aparine*, fig. 1087) are studded with little recurved bristles which prove very effective holdfasts, and the "burrs"

of Burdock (*Arctium majus*, fig. 1088) cling with great tenacity to sheep and other animals. Each burr consists of a number of fruits enclosed by a great many narrow scales, each one of which is bent into a hook at its tip. A different but equally effective arrangement is present in Avens (*Geum urbanum*, fig. 1088). The group of fruits is not surrounded by clinging scales, but each is provided with a long hook. In some foreign fruits the holdfasts are of formidable character, and cause much pain to the unfortunate animals which unwillingly promote dispersal. A well-known instance is that of the Harpoon-Plant (*Harpagophytum*) of South Africa, the large fruits of which are covered with stout radiating projections provided with powerful hooks. They are the source of much inconvenience to such animals as antelopes and lions, being said to sometimes cause the death of the latter.

Fig. 1087.—Fruits of Goose-Grass (*Galium aparine*) covered with Hooks; a few of the hooks, magnified, are shown below

Dispersal of Spores by Animals.—Fleshy fungi are eaten by various insects that swallow vast numbers of the minute spores by which such plants propagate, these passing uninjured through their bodies. In some cases flies are attracted by a sweet fluid (as in Ergot, *Claviceps purpurea*), or by evil-smelling moisture that exudes on the spore-producing surface (as in the Stinkhorn, *Phallus impudicus*). Earth-Worms and other burrowing forms no doubt help to disperse the spores of underground fungi, such as truffles. The last-named plants are also eagerly sought and devoured by pigs, with similar results. The dissemination by animals of disease-producing bacteria is too notorious to require emphasizing.

Fig. 1088.—Group of Hooked Fruits of Avens (*Geum urbanum*) is shown to left, with a single fruit on larger scale. On the right is shown a group of the Fruits of Burdock (*Arctium majus*) surrounded by hooked scales.

CHAPTER LXI

ASSOCIATION OF ANIMALS—COLONIES

Having considered the chief sorts of relation which exist between animals and plants, we have now to deal with the association of individual animals, whether of the same or different species. In the sections on Food and Defences (volume ii) one kind of connection has been treated at considerable length, *i.e.* that which links carnivorous (and to some extent omnivorous) forms with their prey, and we have seen that the bodily structure of both attackers and attacked have been more or less perfectly adapted to the exigencies of attack and defence. Another chapter of the same story will engage our attention rather later on, when Animal Parasites receive consideration, but it will be convenient in the meantime to enter into some particulars regarding other kinds of relation.

Animals of the same species may be associated together in three chief ways, conveniently described under the headings of Colonial Animals, Social Animals, and Courtship and Mating of Animals.

COLONIAL ANIMALS

Colonial Animalcules (Protozoa).—The minute and lowly creatures known as Animalcules are distinguished from animals higher in the scale by the fact that they are single cells or units of structure, *i.e.* they are unicellular. They propagate, as a rule, by splitting (fission) or budding (gemmation), and in a number of species the new individuals which thus come into existence remain connected together, forming a *colony* (fig. 1089). The members of such a colony are usually all alike, each of them performing all the duties of life for itself, and species for which this is true have therefore been described as "physiologically unicellular". Most of them are fixed, as, for instance, in Epistylis

(fig. 1089), which is closely allied to the common Bell-Animalcule (*Vorticella*), a non-colonial form. And another colonial form (*Codosiga*), represented in the same figure, also has solitary relatives. In cases where a number of units are associated together it is clearly advantageous that there should be a "division of labour", on similar principles to those which have increased

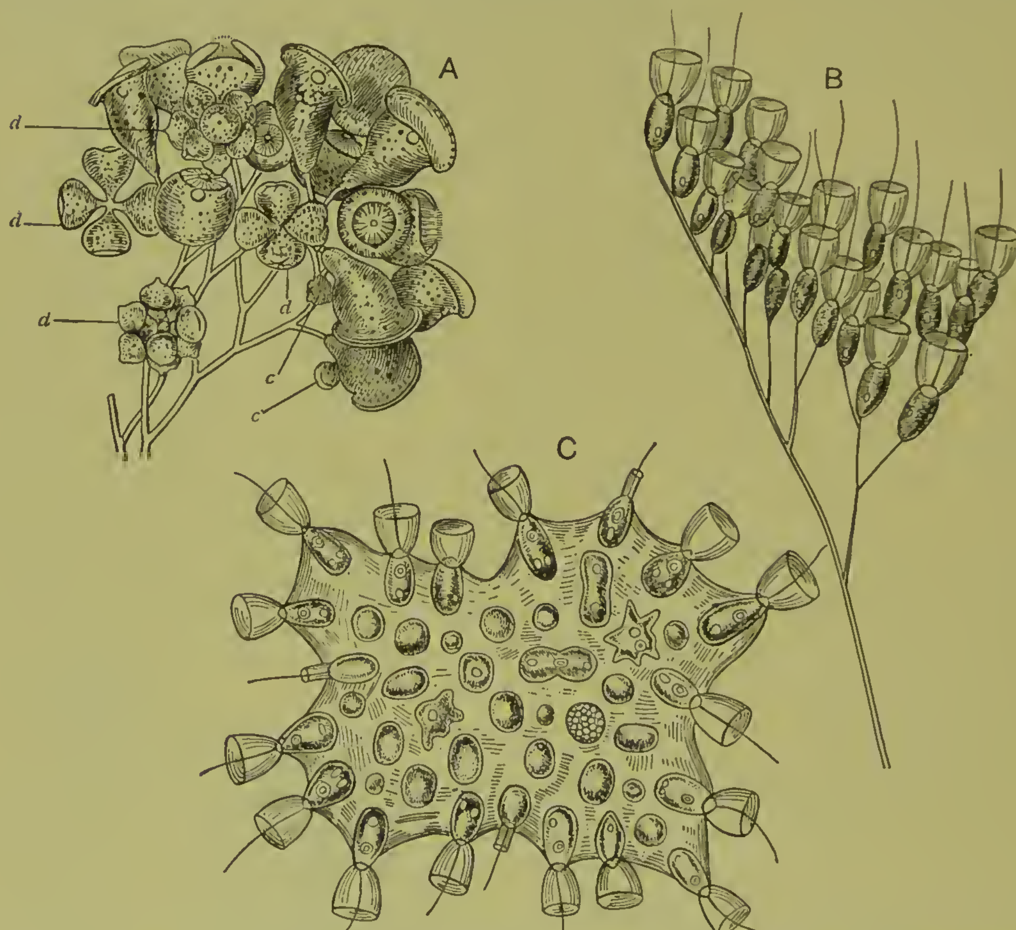


Fig. 1089.—Colonial Animalcules, enlarged to various scales. A, *Epistylis*; *c*, *c*, small individuals conjugating with large ones; *d*, *d*, *d*, *d*, individuals undergoing fission. B, *Codosiga*. C, *Proterospongia*.

the output and improved the quality of manufactured articles. There are certain colonial Animalcules which exhibit an early stage in division of "physiological" labour. Of this an excellent example has already been given (see vol. iii, p. 333) in Volvox, where some members of the colony become specialized in connection with propagation by means of eggs. As another instance we may take Proterospongia (fig. 1089), which consists of numerous individuals imbedded in a gelatinous substance. Some of these are charged with the duty of securing food for the colony, and the projecting end of each such individual is surrounded by a

"collar" from the centre of which springs a thread (flagellum) which executes lashing movements. Within the jelly are other amœba-like individuals, which divide actively, some of the products of division serving to increase the size of the colony, while others are probably liberated to found fresh communities. Proterospongia is of special interest, as it suggests the way in which Sponges have possibly been evolved from simpler animals, for it is characteristic of Sponges that the spaces within their bodies should be more or less lined with "collar cells" that strikingly resemble the collar-provided individuals of the colonial Animalcule just described.

All forms higher in the scale than the Protozoa are collectively known as Many-celled Animals or Metazoa. In any one of these, *e.g.* a Zoophyte, a Worm, or a Mollusc, the body is a more or less complex community of cells, exemplifying in various degree the principle of division of physiological labour, with accompanying specialization. And there can be little doubt that these cell-communities have been gradually evolved from colonial Protozoa. This view has been discussed to some extent in an earlier section (see vol. iii, p. 333).

Colonial Sponges (Porifera).—In this group of animals the colonial condition is the rule, a colony being produced by the budding or incomplete fission of an original individual. Sometimes the members of a community are fairly distinct (see vol. iii, p. 343), but in other cases it is difficult or even impossible to say where one ends and others begin. The absence of sharp boundary-lines between adjacent individuals is well exemplified by a very common British species, the Crumb-of-bread Sponge (*Halichondria panicea*), which may be seen as an encrustation of light-brown colour on rocks near low-tide mark.

Colonial Zoophytes (Cœlenterata).—Vegetative propagation by means of budding or fission is very characteristic of members of this large group, and the buds or fission-products commonly remain united together to form colonies, of which the members are usually clearly marked off from one another. They are united together by what may be termed a "common flesh" (cœnosarc), and their digestive cavities all communicate with a more or less complex system of canals by which this is traversed. It therefore follows that food taken in and digested by one individual may benefit other members of the same community, a

fact which has had much to do with the course of evolution in certain species. Reference should be made to vol. i, pp. 474–481, where some of the Colonial Zoophytes are figured and described, and also to vol. iii, pp. 327–328, for a brief account of the life-histories of such colonies. We are here only concerned with the characteristic features of colonial life, and it will be convenient to consider separately the two sub-groups of Sea-Flowers (*Anthozoa*) and Hydroids (*Hydrozoa*).

Colonial Sea-Flowers (*Anthozoa or Actinozoa*).—To students of the British fauna the most familiar Sea-Flowers are the solitary forms known as Sea-Anemones, which abound on our shores. But in warmer parts of the globe Corals are equally abundant, and these may be either solitary or colonial. The former, or cup-corals, may be compared to anemones, but the lower part of the body is supported by a limy skeleton, while the latter may be regarded as colonies of cup-corals, and present wide variations in shape, according to the mode of growth. In the majority of cases the members of the colony are all alike (fig. 1090), but this is not invariably the case. For in some of the Eight-rayed Sea-Flowers (*Octactinia*), *e.g.* the Sea-Pen (*Pennatula*), some of them are devoid of tentacles, and participate neither in active feeding nor in the production of egg-cells. Their special duty appears to be that of promoting breathing by setting up currents of sea-water which circulate through the fleshy substance of the colony. Ciliary action is the agency employed.

Fig. 1090.—Small Colony of a Coral (*Astroides calycularis*)

Hydroids (*Hydrozoa*).—The branching or encrusting colonies known as Hydroid Zoophytes exemplify division of labour more or less. As we have elsewhere seen, some of the individuals are specially concerned with egg-propagation, and these may be liberated as little free-swimming jelly-fish or medusæ (see vol. iii,

p. 350). This, however, is not the only possibility, as will be seen by reference to fig. 1091, which represents a small part of a species of hydroid (*Aglaophenia*). In addition to the ordinary members of the colony, each provided with mouth and tentacles, there are two kinds of small mouthless individuals. One of these is in the form of a slender thread, which can be stretched out to some little distance, and is possessed of a thickened sticky tip. It acts as a food-catcher, ensnaring small animals to be swallowed and digested by its larger fellows for the benefit of the community. The other kind of mouthless individual is somewhat stouter, and richly provided at its free end with "batteries" of stinging-cells, capable of dealing effectively with larger prey, or warding off the attacks of enemies. When these fighting individuals are called into action, the other members of the colony can be withdrawn into the little cups that surround their bases, being thus out of harm's way.

Fig. 1091.—Small part of a Colony of *Aglaophenia*, enlarged

a, Ordinary individual: *b*, *c*, food-catchers, between them another is seen capturing a crustacean larva; *d*, fighting individual; *e*, digestive cavity of colony; *f*, outer layer of body; *g*, horny investment.

An extreme case of division of labour is presented by the free-swimming colonies of Hydroids known as Compound Jelly-Fish (Siphonophora), which have probably been evolved from simple medusæ by a process of budding (see vol. i, p. 481). The shape of the colony depends upon the way in which this process has been effected. Sometimes the buds have arisen from the "umbrella" of the original medusa, or they may have grown from the walls of the mouth-bearing "handle". The chief kinds of individual that have been thus produced are represented diagrammatically in fig. 1092. The umbrella of the original medusa loses its function as a swimming organ and becomes a float, while (in the case represented) the handle, of which part only is shown, carries a variety of members which contribute in various ways to the common weal of the community. Some are swimming-bells which, by alternately opening and closing, effect propulsion through the water. Others

are transformed into fishing-lines that catch food, and at the same time are so well provided with stinging-cells as to effectively keep off enemies. There are also digestive individuals, which devour and digest the animals caught by the fishing-lines. Some members are reduced to tentacles, ministering to the sense of touch (and possibly smell); others again are in the form of protective plates, covering and sheltering adjacent individuals. And there are also egg-producing members of the colony which may be liberated as little medusæ, thus promoting dispersal. In different species there are considerable variations in detail, and the actual arrangements in one case (*Stephalia corona*) are shown in fig. 1093.

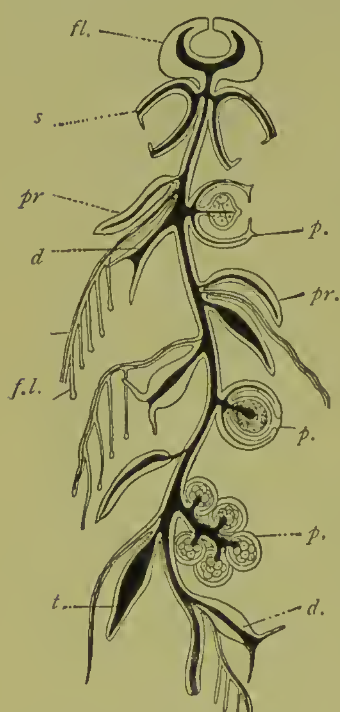


Fig. 1092.—Diagram of various individuals in a colony of Compound Jelly-Fish (*Siphonophora*), central cavity of colony indicated in black. *fl*, Float; *s*, swimming-bell; *d*, *d*, digestive individuals; *f.l.*, branched fishing-line; *pr*, protective individual; *p*, *p*. *p*, various forms of propagative individual; *t*, tentacle.

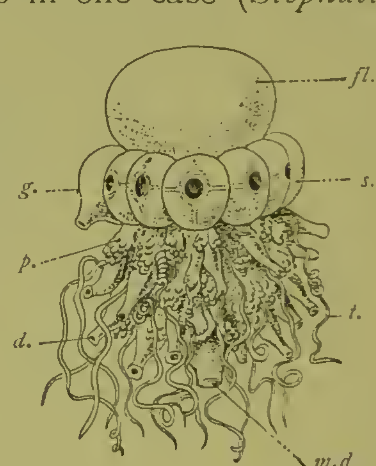


Fig. 1093.—A Compound Jelly-Fish (*Stephalia corona*), reduced. *fl*, Float; *s*, swimming-bell; *g*, gas-conducting individual; *d*, small digestive individual; *m.d.*, large central digestive individual; *t*. tentacle; *p*, group of small propagative individuals.

Colonial Moss-Polypes (Polyzoa).—With a single exception the members of this group produce colonies by budding, after the fashion of Hydroid Zoophytes, for which they are sometimes mistaken, though in reality much higher in the scale. Some of the members of such a colony may be greatly specialized for various purposes (fig. 1094), *e.g.* they may be modified into rounded receptacles (ovicells) in which the eggs develop till the time of hatching. In certain species there are bird's-head individuals, which execute vigorous snapping movements, the object of which is extremely doubtful. Cleanliness is possibly promoted, or perhaps the attacks of small parasitic forms may thus be warded off. It has also been noticed that the powerful jaws often succeed in catching little worms, crustaceans, &c., apparently holding them tenaciously till they die and decompose. The suggestion has been made that the decayed fragments of these victims are carried by

ciliary action into the mouths of the unmodified members of the colony, thus serving as food. But there is no definite proof that such is the case. Individual Moss-Polypes may also undergo still greater modification into whip-like threads that actively lash about in all directions. Cleanliness and defence have here again been suggested as the ends to be served, and cases have been observed where the action is so vigorous as to move the entire colony about. That the surrounding water should be thoroughly stirred up is probably advantageous with reference both to feeding and breathing. The only thing, however, that we definitely know about these curious structures is, that they have been evolved from bird's-head individuals by suppression of the "head", and prolongation of the "lower jaw" into a slender filament.

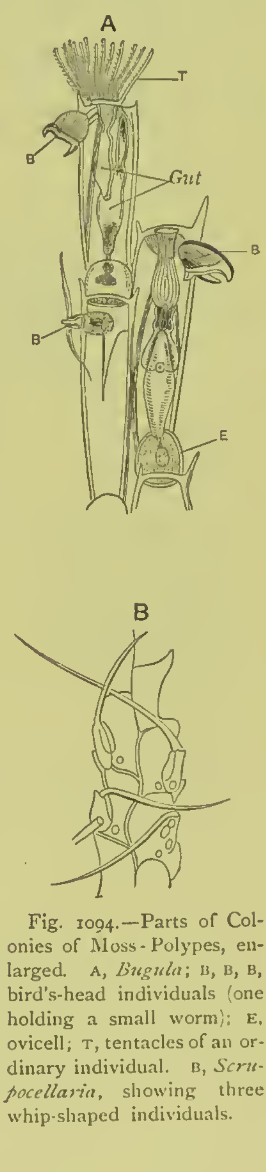


Fig. 1094.—Parts of Colonies of Moss-Polypes, enlarged. A, *Bugula*; B, B, B, bird's-head individuals (one holding a small worm); E, ovicell; T, tentacles of an ordinary individual. B, *Scrupocellaria*, showing three whip-shaped individuals.

Colonial Tunicates (Urochorda).—The formation of colonies is clearly related to powers of increase by means of budding or fission, and consequently all the members of certain animal groups devoid of such powers, *e.g.* Arthropods and Molluscs, are non-colonial. This is also true for the vast majority of Backboned Animals, the most notable exception being afforded by many species of the lowly and degenerate forms known as Sea-Squirts, Tunicates, or Ascidians. Most of these are fixed to some firm object when adult, and their sedentary life has no doubt had much to do with the degeneration they have undergone (see vol. iii, p. 421). A good many Tunicates are non-colonial or "solitary", but others bud to produce colonies of various shape. In such species the individual members may be borne on a creeping stem and clearly marked off from one another, much as in a hydroid zoophyte, or the association may be much more intimate. In the latter case the individuals are sunk within a sort of common body (like the cœnosarc of colonial corals), and there is a continuous protective investment or common test. A good instance is afforded by Botryllus (fig. 1095), to be found at low tide on our coasts as a sort of bluish encrustation on sea-weeds and stones. It

presents at regular intervals a number of flower-like markings, each of which is made up of a circlet of individuals, with their mouths near the tips of the "petals". A small hole in the centre of the flower leads out of a cavity ("common cloaca") into which are discharged the waste products of the members of the group. The surface population of the sea is also partly made up of colonial Tunicates. The Salps, for instance, present two stages in their life-history, one of which propagates by budding, the other by eggs (see vol. iii, p. 422). A large number of the latter stage are connected together when young into "chains", which may be regarded as temporary colonies. These ultimately break up into their constituent members. A notable example of a permanent free-swimming Tunicate colony is afforded by the Fire-Cylinder (*Pyrosoma*, fig. 1095), abundant in the Mediterranean and elsewhere, and giving off a bright phosphorescent light, possibly as a means of protection. The colony is shaped like a hollow cylinder which, in one large species (*Pyrosoma gigantea*), may be as much as 5 feet long, and possesses a contracted aperture at one end, the other being closed. The external surface is covered with pointed projections of the firm test. The small but very numerous individuals are imbedded transversely in the wall of the cylinder, their mouths being external. The large central cavity receives all the products of waste, and is comparable to the common cloaca of a Botryllus circlet. The size of the colony is augmented by budding, and eggs are also produced, which develop into minute colonies that are liberated into the surrounding water, there to grow to their full size.

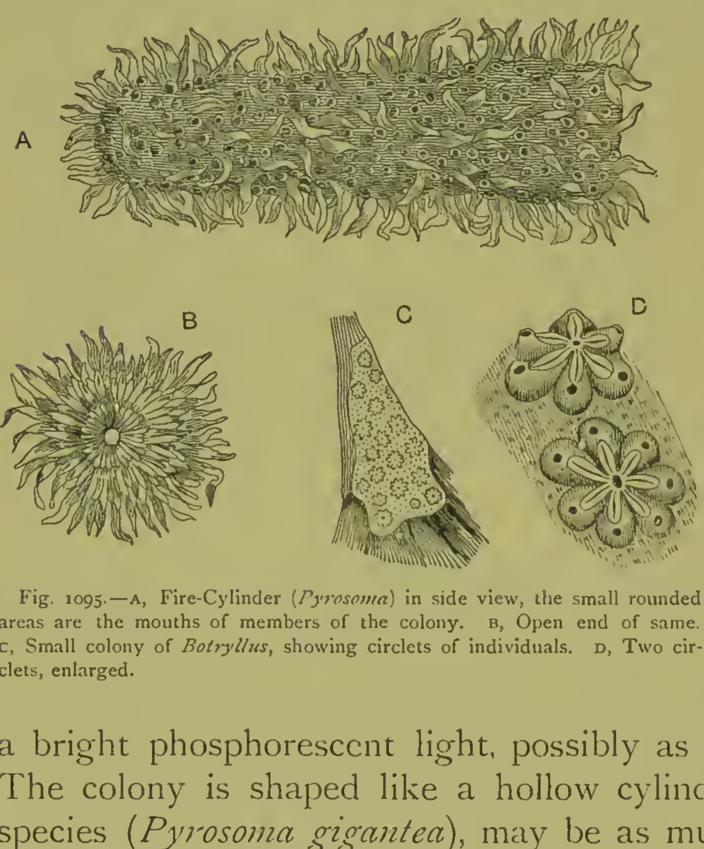


Fig. 1095.—A, Fire-Cylinder (*Pyrosoma*) in side view, the small rounded areas are the mouths of members of the colony. B, Open end of same. C, Small colony of *Botryllus*, showing circlets of individuals. D, Two circlets, enlarged.

CHAPTER LXII

ASSOCIATION OF ORGANISMS—SOCIAL BACKBONELESS ANIMALS (INVERTEBRATA).

Many animals are social or gregarious, and in such cases division of labour between the members of a community is more or less perfectly exemplified. The mere fact that many individuals of the same species live together in the same place does not entitle them to be termed social, in the sense here intended, unless there is some sort of co-operation which benefits the animals living together. It would hardly be justifiable, for example, to describe oysters, cockles, or star-fishes, as colonial animals. But even here the species may be benefited, *e.g.* weakly individuals are weeded out in the keen struggle for existence, so that the stock becomes increasingly healthy and strong. And from such casual kinds of association communities of very complex kind have gradually been evolved, the benefits to be derived from division of labour between individuals giving various species a greatly improved chance of survival in the competition with other species. But here a qualification must be made. For in the world of organisms, by the irony of fate, an extreme penalty attaches to elaborate specialization resulting from adjustment to the exigencies of a certain set of conditions. The surroundings of animals (and plants) are constantly changing, and if these alter suddenly, as they are liable to do, a well adapted species may be unable to adjust itself with sufficient rapidity to the new order of things, and hence be doomed to extinction, while simpler but more plastic forms may survive. Many lowly organisms have endured through countless ages, while others of more complex kind have quickly succumbed to rapid alterations of their environment at a time when their continued dominance seemed most certain. Innumerable instances of this far-reaching principle are to be drawn from the geological record, which preserves for us the past history of the globe.

The most interesting cases of the social habit are to be found among Insects and Backboned Animals, which it will be well to consider separately.

SOCIAL INSECTS (INSECTA)

Some of the most remarkable facts in natural history have been made known by those who have studied the complex communities existing among various species of Membrane-Winged Insects (Hymenoptera) and Net-winged Insects (Neuroptera). The extent to which division of labour is carried varies greatly in different cases, so that we are able to get some notion of the successive stages which have marked the evolution of the social habit.

SOCIAL MEMBRANE-WINGED INSECTS (HYMENOPTERA).—The most salient point distinguishing highly organized communities of Bees, Wasps, and Ants is the presence of a varying number of "castes" or kinds of individual. In the Honey-Bee (*Apis mellifica*), for instance, a hive contains not only males (drones) and an egg-producing female (queen), but also numerous "workers", which are a second kind of female, having nothing to do with the production of eggs, but, as their name indicates, labouring for the benefit of the republic. And in other cases there may be more than three castes, as we shall see in the sequel. Worker honey-bees differ markedly in size and structure from the queen, as the result of a long course of evolution, and it will be desirable to begin with simpler communities, where such sharp distinctions do not exist.

BEES.—Some account has already been given of Carpenter-Bees, Mason-Bees, and Leaf-cutting Bees, solitary forms in which the female not only lays eggs but also makes and stores a nest (see vol. iii, p. 390). These and many other non-colonial insects exhibit very elaborate adaptations to their surroundings, and it would be a mistake to consider them as necessarily lower in the scale than colonial forms, which have evolved on entirely different lines. Here, as in all other cases, success in the struggle for existence may be attained in widely different ways.

From the purely solitary life led by the bees above-mentioned, we pass to a curious case described by Fabre (from his observations in South France), where a certain amount of co-operation is

associated with a large amount of independence. The case is that of certain rather small "short-tongued" bees (species of *Halictus*), which are represented in the British fauna. There are here no workers, but by the united labours of a number of females a branching underground passage is dug out at night, there being a single opening to the exterior, and close to this an enlargement or "hall" for the greater convenience of individuals wishing to pass one another. Within this underground home each female makes her own particular nest, consisting of ovoid waterproof cells, and attends to her domestic duties after the fashion of solitary species. A sentinel is said to be posted at the common opening of the burrow, so that some understanding would seem to be arrived at in the matter of mounting and relieving guard. But, apart from this, the individuals living together have no more social organization than the different families occupying a dwelling made up of a set of "flats", who use a common stair and the same street door. If the said families had constructed these by their joint efforts the analogy would be more complete.

The last example is a sort of side-branch in social evolution; for a comparatively simple case in the direct series of adaptations we may turn to the large insects familiarly known as Humble-Bees (species of *Bombus*), which are well represented in our own country, and live above or under the ground in communities which endure for a single year only. They exemplify the beginning of the caste-system, for in addition to males there are three varieties of the opposite sex, *i.e.* queens, small females, and workers, which in appearance and structure resemble one another pretty closely. We do not find the same marked differences that exist between the queen and worker in honey-bees, while the power of egg-laying is not restricted to the queen, though she is the mother of most of the members of the community. The habits of several species have been closely observed, and the succession of events is somewhat as follows. A queen which has survived the winter begins her work as foundress of a society when the spring is well advanced, and food in the form of nectar and pollen is abundant. Selecting a sheltered spot, on the surface or below the ground according to the species, she successively constructs two or three large waxen cells, the material for which is derived (as in social bees generally) from a number of small glands that open on the under side of her abdomen: a

proportion of pollen being added. When a cell is of full size it is lined with a mixture of pollen and honey, several eggs are laid in it, and a roof is put on. After several days' rest the next cell is made, and stocked in the same way. About the time that the second cell is completed duties of another kind are added to the tale of work. For, meanwhile, the eggs first laid have hatched out, and the bee-grubs, having exhausted their scanty store of provisions, require feeding. To do this their mother bites a hole in the enclosing cell, and supplies honey from her mouth as required. Here, and in other cases, the "honey" is not the same thing as the "nectar" found in flowers. A bee swallows the latter, taking it into a crop or "honey-bag", into which the gullet dilates. Within this receptacle it undergoes a kind of fermentation by which it is converted into honey. So far the life-history is much like that of a solitary form, all the work being done by the mother. But in the next stage division of labour begins to play an important part. The full-fed grubs spin silken cocoons, and pass into the quiescent or pupa stage, from which they emerge as "workers". By gnawing away the wax the queen assists their escape from the enclosing cell. As workers become numerous they justify their name by undertaking the labours of building and storing, ultimately enabling the queen to devote herself entirely to egg-laying. For each egg a separate cell is constructed. As the community increases in size small females may be produced, and towards autumn larger "drone cells" are made, and still larger "queen cells". It is stated that these are not stored with food, the corresponding grubs being from the first assiduously nursed by the workers. By the time that drones and queens are mature the community has attained its full size, and may consist of from 300 to 400 individuals, under favourable circumstances. The pairing of the young queens in the course of a nuptial flight constitutes the climax of the year's drama, for as winter approaches the temporary community becomes disintegrated. All the workers and drones perish, together with many of the queens, but some of the latter live through the winter in a torpid state to found fresh societies the following spring. It should be added to this account that when the community is in full working order special unclosed cells are made, to be stored with honey or pollen for general use. These "honey tubs" and "pollen tubs" serve as a larder, which

is constantly being replenished during fine weather, to be drawn upon when it is wet. Old brood-cells may be enlarged for the same purpose, but are never put to their original use a second time.

For one species of Humble-Bee (*Bombus ruderatus*) a remarkable arrangement has been described. It is said that in every nest one bee is told off as a "trumpeter". This individual sounds *reveillé* at from 3 to 4 a.m., rousing her fellows to the labours of the day, and if removed is replaced by another. The habit of storing food, existing to some extent in Humble-Bees, is carried much further in the Honey-Bee (*Apis mellifica*) and its numerous relatives, and has probably had much to do with the evolution of the complex social life which these exhibit. It enables a community to live on through the unfavourable season of the year, thus becoming permanent, and this continuity has rendered possible division of labour to a greater degree, being at the same time associated with well-marked differences between the castes, so far as queen and workers are concerned. The former is of comparatively large size, and her only duty is to produce eggs, while the varied labours of the hive fall to the lot of her smaller sisters. The community is only temporary as regards the drones, none of which survive the winter, but are replaced by a fresh set which hatch out the following year. A few further details regarding the Honey-Bee will be given in a later section.

The Social Wasps (*Vespidæ*) live in communities which, so far as at present known, exist for one season only, as in Humble-Bees, to which they present a further resemblance in the fact that the workers are not markedly unlike the queen, and are more or less capable of laying eggs. The building-material, however, is not wax but a sort of paper, made by chewing woody matter and mixing it with a fluid secreted by certain glands of the mouth-region. We may take to illustrate the annual cycle one of three British species (*Vespa Germanica*, fig. 1096) in which the nest is constructed underground. The foundress queen begins work in spring, making a small number of cells in the place which is to be the top of the nest, and depositing an egg in each. The cells are neither stored nor closed. Her next task consists in feeding the grubs as they hatch out, first with honey or fruit-juice, and later with the bodies of insects, especially flies. By

means of her strong jaws she removes the hard parts of the prey, chewing up the rest into a kind of mince-meat adapted to the tender digestions of her offspring. When they have reached their full size the grubs spin cocoons and pass into the pupa stage, from which they emerge as worker wasps about four weeks after the date when the eggs were laid. Without loss of time these take over the work of building and nursing, and even feed their mother, who soon has nothing to do but lay eggs in the cells as they are constructed. The complete nest consists of a series of combs, connected by little pillars, and the building operations are carried on from above downwards. Each comb is made up of a large number of roughly hexagonal cells, the mouths of which are directed downwards. Towards the end of summer cells of larger size are made, in which queens and drones are reared, but many of the latter are brought up in the ordinary small cells. After mating has taken place the community is soon broken up; most of the insects die, but some of the queens survive the winter, and found the communities of the following year. Wasps appear to be extremely sensitive to cold, and it is perhaps partly for this reason that the nest is surrounded with a covering made up of layers of paper (see fig. 1096).

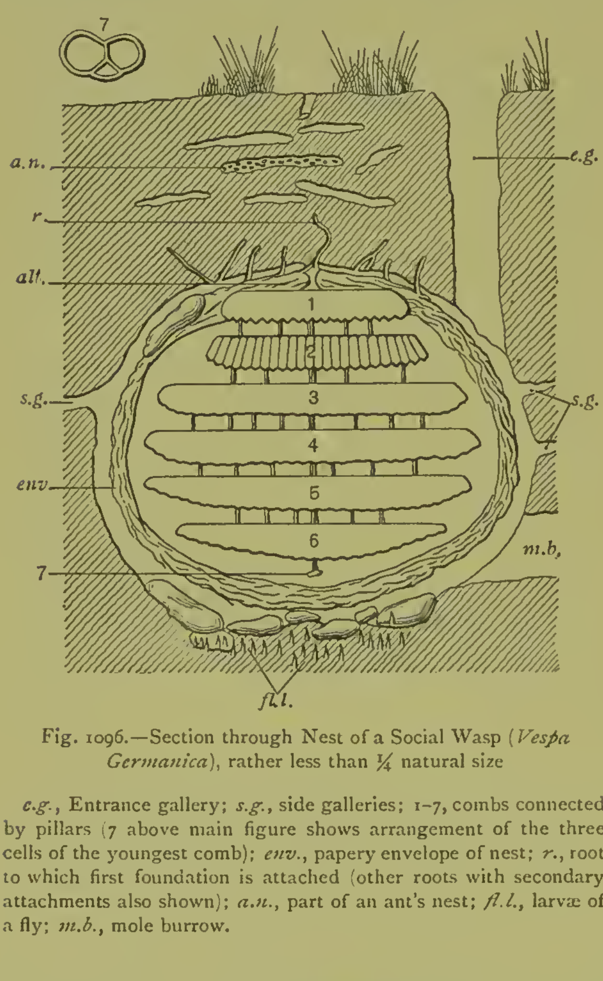


Fig. 1096.—Section through Nest of a Social Wasp (*Vespa Germanica*), rather less than ¼ natural size

e.g., Entrance gallery; *s.g.*, side galleries; 1–7, combs connected by pillars (7 above main figure shows arrangement of the three cells of the youngest comb); *env.*, papery envelope of nest; *r.*, root to which first foundation is attached (other roots with secondary attachments also shown); *a.n.*, part of an ant's nest; *fl.l.*, larvæ of a fly; *m.b.*, mole burrow.

The nests of many species of social Wasp are suspended from plants, while the Hornet (*Vespa crabro*) prefers to build in a hollow tree. There is a large amount of variation as to size, shape, and durability, while in some cases earth is added to the ordinary building material.

The social habits of Ants are even more complex than those of Bees and Wasps, and some account has already been given of the way in which the members of certain species procure and store food (see vol. ii, pp. 103 and 206). There is no more fascinating department in the whole realm of natural history than the study of ant life, for these little creatures live in a wonderland which is all their own. The elaboration of some of their communities is very considerable, and the welfare of the individual is rigorously subordinated to the interests of the species. Some of the more salient points are thus ably summarized by Sharp (in *The Cambridge Natural History*):—"Observation has revealed most remarkable phenomena in the lives of these insects. Indeed, we can scarcely avoid the conclusion that they have acquired in many respects the art of living together in societies more perfectly than our own species has, and that they have anticipated us in the acquisition of some of the industries and arts that greatly facilitate social life. The lives of individual ants extend over a considerable number of years—in the case of certain species at any rate,—so that the competence of the individual may be developed to a considerable extent by exercise; and one generation may communicate to a younger one by example the arts of living by which it has itself profited. The prolonged life of ants, their existence in the perfect state at all seasons, and the highly social life they lead are facts of the greatest biological importance, and are those that we should expect to be accompanied by greater and wider competence than is usually exhibited by Insects. There can indeed be little doubt that ants are really not only the 'highest' structurally or mechanically of all insects, but also the most efficient. There is an American saying that the ant is ruler of Brazil. We must add a word of qualification; the competence of the ant is not like that of man. It is devoted to the welfare of the species rather than to that of the individual, which is, as it were, sacrificed or specialized for the benefit of the community. The distinctions between the sexes in their powers or capacities are astonishing, and those between the various forms of one sex are also great. The difference between different species is extreme; we have, in fact, the most imperfect forms of social evolution coexisting, even locally, with the most evolute. These facts render it extremely difficult for us to appreciate the ant; the limitations of efficiency displayed by the individual being in some

cases extreme, while observation seems to elicit contradictory facts. About two thousand species are already known, and it is pretty certain that the number will reach at least five thousand."

The caste-system is well-marked among Ants, and there are at least three sorts of individual, males, queens, and workers or modified females. The two former are commonly winged, and pairing usually takes place in the air. After this has been accomplished the males soon die, while the females cast, or it may be bite off, their wings, and enter upon their further duties. In some species the male alone possesses wings, while it more rarely happens that the contrary is true. Cases are also known where both kinds of male exist in the same species, the female being winged, or both kinds of female are associated with winged males. There may also be distinct castes of workers, one consisting of large individuals (workers major), and the other or others of small ones (workers minor). In many cases, too, there is a caste of "soldiers" distinguished by the great size of their mandibles. Like workers they are modified females. To all intents and purposes, indeed, the societies of Ants, like those of Bees and Wasps, are female republics. The "queen", it is true, has all her wants attended to by the workers, but does not actively direct the affairs of the community, having no special authority. The care bestowed upon her, indeed, would appear to be simply in recognition of the fact that she is necessary for the continuance of the society. In ant-societies there may be more than one queen. There appears to be no doubt that these insects are able to communicate certain kinds of information to one another. Indeed, without some power of communication there would be endless confusion in a large community. As it is, we find that foraging expeditions, warfare, and the complex economy of the nest are all carried out in an orderly fashion. In human societies even republics require some sort of government for the direction of individual efforts, but this often appears not to be the case here. The armies of our native species, for example, so far as we know, are entirely made up of rank and file, without officers and non-commissioned officers. Yet such an army often seems to conduct its campaigns strategically, and deals very effectively with tactical problems which arise after it has taken the field. How this is possible we are not yet able to say, for our own mental powers have been evolved on very different lines. There is certainly a basis of instinct, *i.e.* inherited

capability of doing certain things on impulse when appropriate occasions present themselves; but since individual ants profit largely by experience, we may also say without hesitation that many of their actions are intelligent. There can be little doubt that young workers receive a practical education in their duties, learning by example if not by precept. If so, we have a very convincing proof of marked intelligence. Where, as in some tropical ants, there are numerous castes, the mental life of the community is probably more complex, but comparatively few observations have been made on this difficult subject.

The early stages in the formation of societies have been observed in some species, and are probably substantially the same in all. A foundress queen lays her first batch of eggs, and carefully tends the larvæ when they hatch out, until they pass into the pupa stage, from which they emerge as workers, who at once concern themselves with the industrial work of the young community. The queen is therefore soon able, as in the ordinary social wasps and bees, to restrict herself solely to the duty of egg-laying. One important point in the domestic economy of all ant-societies may here be mentioned. Special cells of paper or wax are not constructed for the reception of eggs, as in Bees and Wasps, but these are deposited in chambers, variously situated, according to the species. It is further to be noted that the larva may or may not spin a cocoon before passing into the pupa state. When a cocoon is made it is removed by the workers at the proper time, so as to facilitate the escape of the perfect insect.

There is a large amount of variation as to the number of individuals contained in an ant-society. This is very large in most of the kinds which have been carefully studied, and it is naturally so in cases where the social life is very complex. Simple instances are afforded by some of the Indian Ants (species of *Polyrhachis*), where a single queen and less than a dozen workers live together in a little one-chambered dwelling that looks almost like a miniature bird's-nest, and is constructed of a papery substance with a lining of silk. These small homes are found on leaves, and are commonly so placed or made as to be inconspicuous. Another sort of Asiatic Ant (*Œcophylla smaragdina*) lives in larger communities upon foliage, of which the leaves are converted into dwellings in a very remarkable manner. The workers roll them up and fix their edges together by means of a viscid fluid derived

from the silk-glands opening near the mouths of the larvæ. A worker engaged in this task holds a larva firmly in her jaws, and holds it to the required spot, using it in fact as a living gum-bottle.

Some of the leading features in the communal life of a large society of the industrious insects under discussion may be learnt from the study of our largest native species, the reddish-coloured Wood-Ant or Horse-Ant (*Formica rufa*). It abounds in the fir-woods of our southern counties, where the large "ant-hills" which it constructs are conspicuous objects. The winged males and females are not far short of half an inch in length, and there are two kinds of worker, which are respectively about one-fourth, and from one-fifth to one-sixth of an inch long. The nest may be nearly three feet high and some eighteen feet round at its base, and is made up of fir-needles, together with all sorts of plant fragments. The vicinity of the nest is trodden down into a number of "ant-roads", which are the scene of much busy going and coming. The larger workers are principally concerned, when outside the nest, with collecting building materials, while an important duty of the smaller workers is to collect the "honey-dew" of aphides, insects which are often picturesquely described as "ant-cows". The substance in question is a sugary fluid that exudes in considerable amount from the intestines of these little creatures, and is eagerly swallowed by the workers, a great deal of it passing into their dilated crops. Having filled themselves up with this desirable food, the workers hurry back to the nest, and obligingly distribute some of their store for the benefit of the larvæ, and their adult friends who have meanwhile been engaged with the internal economy of the nest. There are no special receptacles corresponding to the honey-tubs of humble-bees or comb-cells of ordinary bees, for storage of what is not immediately needed. Indeed none of our native ants indulge in the luxury of a larder, and remain in a torpid condition during the winter. The food is by no means limited to honey-dew, but is of very mixed nature, for caterpillars, various adult insects, and miscellaneous vegetable matter all figure in the bill of fare. There is a constant return of foraging parties to the central home (fig. 1097).

The ant-hill is literally riddled with labyrinthine galleries expanding at intervals into rounded chambers, and for some depth the underlying ground is mined with passages continuous with those above. It is easier to destroy an ant-hill than to get any

clear idea of its internal economy, but J. G. Wood (in *Insects at Home*) thus describes a very ingenious device by which he was enabled to gain some knowledge of the kind:—"I have, however, succeeded in obtaining an excellent view into the interior of a Wood-Ants' nest, though it was but a short one. Accompanied by my friend Mr. H. J. B. Hancock, I was visiting some remarkably fine Wood-Ants' nests near Bagshot. We took with us a large piece of plate-glass, placed it edgewise on the top of an ant-hill, and, standing one at each side, cut the nest completely in two,

Fig. 1097.—Horse Ants (*Formica rufa*) collecting Food and Building Materials

leaving the glass almost wholly buried in it. After the expiration of a few weeks, during which time the Ants could repair damages, we returned to the spot, and, with a spade, removed one side of the nest as far as the glass, which then served as a window through which we could look into the nest. It was really a wonderful sight. The ant-hill was honey-combed into passages and cells, in all of which the inhabitants were hurriedly running about, being alarmed at the unwonted admission of light into their dwellings. In some of the chambers the pupæ were treasured, and these chambers were continually entered by Ants, which picked up the helpless pupæ and carried them to other parts of the nest where the unwelcome light had not shown itself. Unfortunately, this view lasted only a short time."

The most important and arduous duty of the workers is to look after the eggs, larvæ, and pupæ, and these are distributed through the nest with due regard to variations of moisture and temperature, since both of these affect development. The queens are carefully tended, and their eggs are carried off to suitable chambers. From time to time these are carefully licked, and it is also said that they are smeared with nutritious fluid that is absorbed by the embryos. When the larvæ hatch out they are fed with great assiduity and their toilet requirements attended to. The full-grown larvæ spin cocoons, within which they become pupæ (the so-called "ants' eggs"), which also receive unremitting attention. The workers bite away the enclosing cocoons when the perfect insects are ready to come out. Some of them are workers, others winged males and females which fly about in swarms. After mating, the large majority of the swarming individuals perish, but some of the females survive to found fresh communities, or sometimes to be taken into existing nests.

The stings of Wood-Ants are not sufficiently well developed to be of use, but their poison-bags contain formic acid, which can be squirted to a considerable distance, and is an effective defence. This particular acid, as its name indicates (L. *formica*, an ant), was first known as a product of insect-life. The strong mandibles of the workers are also weapons of no despicable character. These ants co-operate for offence and defence, and Lord Avebury (in *Ants, Bees, and Wasps*) thus describes their tactics, and those of a related species:—"*Formica rufa*, the common Horse Ant, attacks in serried masses, seldom sending out detachments, while single ants scarcely ever make individual attacks. They rarely pursue a flying foe, but give no quarter, killing as many enemies as possible, and never hesitating, with this object, to sacrifice themselves for the common good. *Formica exsecta* is a delicate, but very active, species. They also advance in serried masses, but in close quarters they bite right and left, dancing about to avoid being bitten themselves. When fighting with larger species they spring on to their backs, and then seize them by the neck or by an antenna. They also have the instinct of acting together, three or four seizing an enemy at once, and then pulling different ways, so that she on her part cannot get at any one of her foes. One of them then jumps on her back and cuts, or rather saws, off her head. In battles between this ant and the much

larger *F. pratensis*, many of the *F. exsectas* may be seen on the backs of the *F. pratensis*, sawing off their heads from behind." Such practices would be greatly deprecated in human warfare.

Some of the most remarkable features in ant-life have reference to the use they make of aphides (fig. 1098), and some species, instead of merely sallying forth to collect honey-dew, in the way described above for the Wood-Ant, have advanced to the pastoral stage of social life, and may be described as cattle-keepers. This is well illustrated by our native species of Lasius. The common little Black Garden-Ant (*Lasius niger*), which lives in elaborate underground dwellings, is particularly partial to aphides which live on twigs and leaves, moving them to convenient places for "milking" operations, and carrying their eggs into its sheltered home for the inclement winter season. The small Yellow Ant (*Lasius flavus*), another underground species, goes further than this, for Lord Avebury states that four or five distinct kinds of aphis are found in some numbers in its nest, belonging to root-feeding species. The same observer made some most interesting observations (on captive specimens) of the way in which (like *L. niger*) these ants tend another sort of aphis, which is not a root-feeder, and he gives the following summary of the facts (in *Ants, Bees, and Wasps*):—"Here are aphides, not living in the ants' nests, but outside, on the leaf-stalks of plants. The eggs are laid early in October on the food-plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, exposed to the severity of the weather and to innumerable dangers, but brought into the nests by the ants, and tended by them with the utmost care through the long winter months until the following March, when the young ones are brought out and again placed on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter; but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer, a case of prudence unexampled in the animal kingdom." It should be added that after carrying the young aphides to the appropriate food-plant the ants wall them in with earth, and the enclosures thus made may be almost

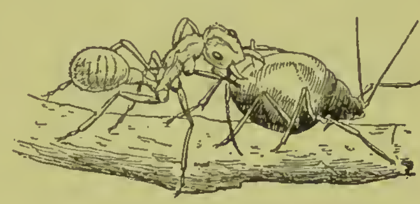


Fig. 1098.—Ant (*Myrmica rubra*) "Milking" an Aphis (*Aphis sambuci*)

called "cattle-pens." Some remarks will be made in a subsequent chapter on ants as slave-owners, and on the beetles, &c., which live in their nests.

The caste-system is carried to an extreme in one of the common Foraging-Ants (*Eciton hamata*, see vol. ii, p. 104) of Tropical America, a carnivorous species which possesses a powerful sting. Besides winged males and wingless females there are "soldiers" with enormous jaws, large workers, and two sizes of small worker. These ants and those of allied species have no permanent abode, but wander about from place to place after the fashion of armies. After carrying on offensive operations for some time they construct temporary quarters, where they cultivate the domestic virtues and bring up their offspring. Belt gives the following account of ants of the sort in regard to this matter (in *A Naturalist in Nicaragua*):—"They make their temporary habitations in hollow trees and sometimes underneath large fallen trunks that offer suitable hollows. A nest that I came across in the latter situation was open at one side. The ants were clustered together in a dense mass, like a great swarm of bees, hanging from the roof, but reaching to the ground below. Their innumerable long legs looked like brown threads binding together the mass, which must have been at least a cubic yard in bulk, and contained hundreds of thousands of individuals, although many columns were outside, some bringing in the pupæ of ants, others the legs and dissected bodies of various insects. I was surprised to see in this living nest tubular passages leading down to the centre of the mass, kept open, just as if it had been formed of inorganic materials. Down these holes the ants who were bringing in booty passed with their prey. I thrust a long stick down to the centre of the cluster, and brought out clinging to it many ants holding larvæ and pupæ." Ants as agriculturalists and mushroom-growers have been dealt with in an earlier section (see vol. i, p. 207).

Social Net-Winged Insects (Neuroptera).—The interesting social insects known as Termites live in complex communities somewhat resembling those of Ants, with which, under the name of "White Ants", these forms are often confounded. The resemblance, however, is very superficial, while the differences are profound. Termites are not invested in strong plate-armour, their exo-skeleton being comparatively thin, nor do they possess poison-

glands or stings. But the jaws of the individuals which do the work of the community are very powerful, as in Ants. Most species shun the light and are pale in colour (hence the name "White" Ants), and in such cases only the kings and queens possess eyes, the other castes being blind. There are, however, leaf-cutting Termites in South Africa which move about in open daylight. Eyes are here present in all castes. There is no marked metamorphosis, for the young do not hatch out of the egg as helpless grubs, but as active nymphs, which attain their full size after several moults. The number of castes varies greatly in the different species, and matters are complicated by the presence of nymphs in various stages of development. But in all cases which have been investigated the just-hatched nymphs are to all appearance alike, and it is probable that their subsequent fate depends upon the nature of the food, the matter being more or less regulated by the mature inhabitants of the nest. The same thing is, indeed, largely true for social Bees and Wasps. In the Honey-Bee, for example, the grubs destined to become queens are fed differently from their fellows.

Only the fully mature queens and kings (as the full-blown males are here usually termed) are provided with wings, both pairs being of equal size, the arrangement of veins being quite unlike that characteristic of Bees and Wasps, as might be anticipated from the fact that Termites belong to an entirely different order. Near the base of each wing there is a weak place, facilitating detachment after the first and only flight has taken place. Queens and kings swarm from the nest much as in Ants, and associate themselves in pairs. The vast majority fall a victim to insectivorous birds and other animals, but enough survive to secure the formation of fresh societies, at least in some cases. Nor do we find that speedy death is the necessary sequel to mating for a king termite, as in the case of drone bees, for a nest commonly contains, in some species at any rate, a royal couple, both of whom are carefully tended for the term of their natural lives. Of other kinds of individual, soldiers are always found and generally workers, some of both these castes being modified females and others modified males. A Termite society is not, like those of Bees and Wasps, a female republic.

The only two known species of European Termite have been carefully studied, in Sicily, by Grassi and Sandias, whose chief

results will be briefly summarized. The societies of some of the African forms are still more complicated, but here our knowledge is in many respects very incomplete, though it may prove interesting to give a few details. Rather more than 100 species of Termite have been so far described, and these are probably only a tithe of those which actually exist. They abound in the tropical and warmer temperate regions of the world.

The Yellow-Necked Termite (*Calotermes flavicollis*) of the Mediterranean littoral is of peculiar interest, for its communities are small (under 1000 individuals), and the habits are comparatively simple. The home is a hollow within a dead or decaying tree, and the architectural operations are limited to increasing the size of the hollow as may be necessary, and making partitions or the like with waste matter ejected from the intestine, saliva being employed as a cement. Within this simple home are found a king and queen, together with a number of soldiers and nymphs. There are no workers. The soldiers are distinguished, as in Termites generally, by the possession of huge heads and formidable jaws. The habits as regards food are somewhat remarkable, and promote sanitation of the nest in an unusual degree. Wood is the staple diet, but it is a substance very difficult of digestion, and the pellets which are voided from the intestine are eaten again and again, until their nutritive properties are exhausted, when they are either employed as building materials, heaped up in remote parts of the nest, or dropped outside. Partly digested food may also be ejected from the crop, suggesting the arrangement found in other social insects as regards sweet substances. The salivary secretion is also highly nutritious, and not a mere digestive juice. All the cast skins are used as food, and burial rites are simple, the bodies of deceased friends augmenting the bill of fare. The young nymphs are fed at first on saliva, from which they are promoted to material ejected from the crop and intestinal pellets, wood pure and simple being eaten more or less at a still later stage. A grim sort of fate attends the soldiers, for their huge jaws would appear to cut them off from the most abundant items in the dietary, and they are driven to cannibalism. Not only do they devour the dead, but shorten the sufferings of the sick and dying by eating them alive. It is supposed that they are in a state of permanent hunger, and

may be well excused for sometimes doing a little private slaughter among their healthy relatives, as they are said to be apt to do when excited. It is on the whole a good thing that human social life has evolved on rather different lines, in spite of the horrors of war and other matters which an intelligent Termite would deprecate.

Winged queens and kings swarm from the nest at certain seasons of the year, and any pair fortunate enough to escape the appetites of birds or other foes is capable of starting a fresh society.

The Light-shunning Termite (*Termes lucifugus*) is the second and only other European species. A society consists of many thousands of individuals, and there are workers as well as soldiers. Winged queens and kings swarm from the nest as in other cases, but in Sicily these all perish, so far as yet known. It seems probable, however, that the existing societies there were founded in the first instance by royal pairs, though Grassi has never found these in any of the very numerous Sicilian nests he has examined. In France, however, the investigations of Perris and Perez show that in that country communities can be founded in the usual way. Since fresh individuals are constantly being produced in the Sicilian nests, we naturally enquire how this is possible in the absence of true queens and kings, *i.e.* termites which at one time possessed wings and were fully adult. The answer is found in the existence of remarkable castes which may be termed "substitution royalties". Here, as in other species with complex social life, the workers seem to be aware of the necessity for continued egg-production, and appear to feed some of the nymphs in such a way that they become capable of continuing their kind, though wings are not developed, and certain immature characters are retained. The substitution queens and kings are not all alike, as may be gathered to some extent from fig. 1099. Even this apology for a king is rarely found in a nest, a possible explana-

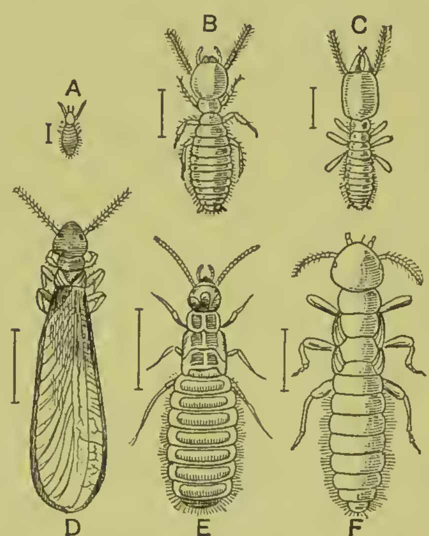


Fig. 1099.—Light-Shunning Termite (*Termes lucifugus*). A, Young larva; B, adult worker; C, soldier; D, winged adult; E and F, reserve or substitution queens. Actual sizes indicated by the vertical lines.

tion being that this particular species is given to regicide, though this would be contrary to the usual habit of Termites. The following table (modified from Grassi) will show the various kinds of individual that have been found in the dwellings of *Termes lucifugus*:—

- 1. Young, undifferentiated nymphs.
  - 2. Nymphs that are not to be concerned with egg-production.
    - 5. Soldier nymphs.
      - 7. Soldiers.
    - 6. Worker nymphs.
      - 8. Workers.
  - 3. Nymphs that will be concerned with egg-production.
  - 4. Reserves for royalties (present if 14, 15, and 11 are absent, or 14 and 15 not sufficiently numerous).
    - 9. Nymphs of the first form.
      - 12. Winged insects.
        - 14. True royalties.
      - 13 Reserve royalties (?).
    - 10. Nymphs of the second form.
      - 15. Substitution royalties.
    - 11. Reserves for royalties (present if 14, 15, and 4 are wanting, or if 15 and 4 are not sufficiently numerous).

When we remember that the societies of this and other species may exist for a very long time, the reason for the production of substitution royalties becomes tolerably clear. We may suppose that a society is in the first instance founded by a fully-developed royal pair, after they have shed their wings. When a sufficient number of workers have been matured to do the ordinary work, the royal pair for the rest of their lives are carefully tended (though possibly in some species the king may be destroyed), being afterwards replaced by substitution royalties, devoid of wings, these being unnecessary under the circumstances. Provision would, of course, be made for a continuous succession of queens and kings of this kind, and the society would only die out when the environment became in some way very unfavourable.

The Light-shunning Termite lives in wood, like the Yellow-necked species, but its building operations are much more elaborate. Complex galleries and chambers are tunnelled out, and, as before, the exhausted intestinal pellets are employed in constructive work, the cement being saliva. The same sorts of food are used as in the other species.

The societies of certain Termites native to tropical Africa are the largest and most complex yet discovered, though our knowledge regarding them is unfortunately very incomplete. The most famous species is the Warrior Termite (*Termes bellicosus*),

which was long ago investigated by Smeathman in West Africa. His description in the *Philosophical Transactions* for 1781 is astonishingly correct, considering the date at which it was written. Each of the vastly numerous communities constructs and lives in a wonderfully solid dwelling in the form of a mound that may be as much as 20 feet high, and is shaped something like a sugar-loaf. It is chiefly made of earth glued together with saliva, while a good deal of the interior work is carried out with the materials already mentioned for other species. A single

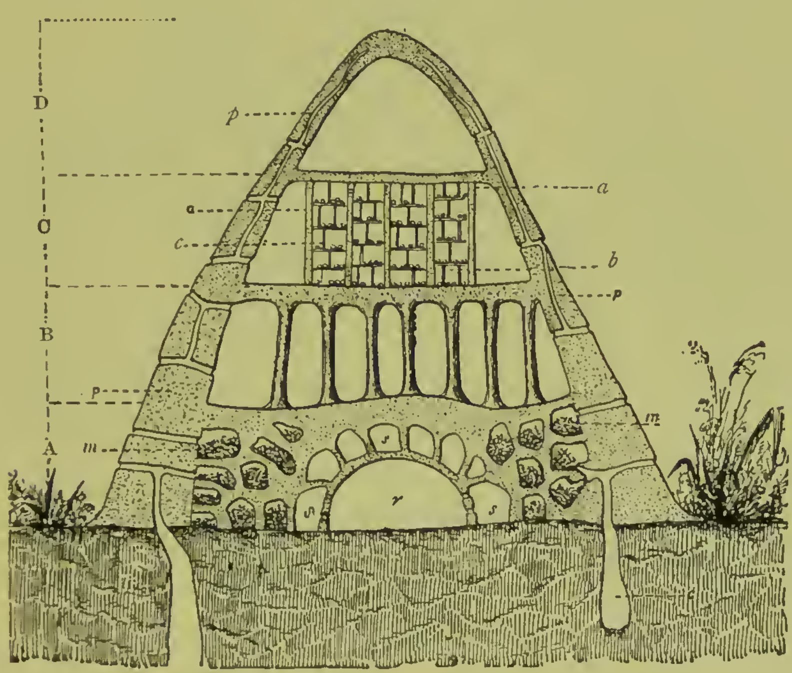


Fig. 1100.—Section through Mound of Warrior Termite (*Termes bellicosus*), greatly reduced. For description see text.

royal couple constitute the centre of social life, and there are both worker and soldier castes, the members of the former being much the larger. The name "soldier" is not altogether a happy one, for it appears that the workers fight much better, while the supposed military individuals are rather fond of looking on. Below the termite dwelling (fig. 1100) are excavations (*c*) from which earth for building is procured, while the dwelling itself is divided into four stories (A–D), surrounded by a common external wall (*p* on left), which is traversed by transverse and longitudinal galleries (*p* on right). The centre of the ground-floor (A) is occupied by the royal chamber (*r*), which is of considerable size, and enclosed by a curved wall in which there are numerous

apertures, giving free access to the workers, and furthering ventilation. The king lives here of his own free-will, while the queen is obliged to be a prisoner, for her abdomen is so filled with eggs as to be of relatively enormous size. Attendant crowds of workers are constantly to be found within the royal chamber, attending to the various wants of the king and queen, and carrying away the eggs, which are sometimes laid at the rate of 60 per minute (fig. 1101). Numerous worker-dwellings (*s*) adjoin the abode of their titular sovereigns, and the outer part of the ground-floor is

Fig. 1101.—Royal Cell of Warrior Termite (*Termes bellicosus*), broken open to show queen (Q) and her attendants *e* (on left), Openings into royal cell; *e* (on right), an opening that has been closed up; about ⅔ natural size.

occupied by numerous store-chambers (*m*) in which are heaped up gums and other dry vegetable products. The first floor (B) is a large pillared hall, which has no known use except that of serving as an air-space. The second floor (C) may be called the "nursery", for here the eggs are hatched out, and the young nymphs carefully tended. The space is subdivided by means of strong vertical partitions (*a*), and the central portion is marked off into a large number of small compartments (*b*), separated from one another by more delicate party-walls (*c*). The third story or attic is simply an air-space. It will be noted that the arrangements are such as to further the maintenance of equable conditions as regards temperature and moisture, to variations in which Termites appear to be particularly sensitive.

In concluding this chapter it may be noted that the larvæ of many insects are found feeding together in "companies", which have hatched out from batches of eggs laid at the same time and place. Probably the most remarkable case of associated larvæ is afforded by the maggots of certain of the little two-winged flies known as Fungus Gnats (*Mycetophilidæ*). One of these is familiar as the "Army Worm" (*Sciara militaris*) of Europe, and allied forms are native to the United States. The maggots live among rotting leaves, and are sometimes found moving from place to place, united together by sticky threads, and writhing along like a snake. The largest armies of this sort may include millions of individuals, and are stated to reach an extreme length of 100 feet, with a breadth of 6 inches, and a depth of 1 inch. The migrations are probably dependent on the question of food-supply.

CHAPTER LXIII

ASSOCIATION OF ORGANISMS—SOCIAL BACKBONED ANIMALS (VERTEBRATA)

That many backboned animals are of gregarious habit is too well known to require emphasis. Our vocabulary includes many words signifying communities of animals, *e.g.* we speak of a "shoal" of fishes, a "flock" of birds, a "pack" of wolves, a "herd" of antelopes, and so on. The societies of which the existence is implied by many such words exhibit a type of communal life differing greatly from that described for insects, and one that is in some respects less interesting, except in so far as it throws light on the problems of sociology, with which all intelligent persons are more or less concerned. The complex conditions resulting from numerous individuals living together have not here led to profound anatomical specialization, as they have in the case of such insects as ants.

SOCIAL FISHES (PISCES).—That so many Fishes should be associated together in shoals would seem to be dependent in many instances on the place and manner of spawning. In ordinary bony fishes (Teleostei) the eggs are nearly always fertilized externally, and it is obvious that this process is facilitated when numerous individuals seek the same locality for the purpose. The Herring (*Clupea harengus*), fig. 1102), for example, approaches our shores in order to deposit its eggs in shallow water, where they adhere to various objects; the Salmon (*Salmo salar*) ascends rivers for the same purpose; and the Common Eel (*Anguilla vulgaris*) migrates in vast numbers to the deep sea in order to spawn. How far the movements of migratory fish involve division of labour is not at present known. It is not impossible that some of the older individuals may act as "leaders", though this is little more than a conjecture.

The gregarious habit of many predaceous fishes, such as Sharks, Dog-fishes, and Mackerel, may conduce to success in

procuring prey, and certainly gives an opportunity for co-operation to the benefit of the community. On the other hand, living in shoals must tend very greatly to increase mortality among ill-defended species, which thus are bound to attract the notice of their foes. The well-being of the individual is here, as generally, subordinated to the interests of the species, the matter apparently being determined by the exigencies of spawning.

Though some of the Amphibians and Reptiles may be more or less gregarious, but little of interest is known about them in

Fig. 1102.—Part of a Shoal of Herrings (*Clupea harengus*)

the present connection, so that we may pass on to the more intelligent animals included in the two highest vertebrate classes, *i.e.* Birds and Mammals. A comparatively large and complex brain is here associated with sagacity that may make itself manifest in social developments.

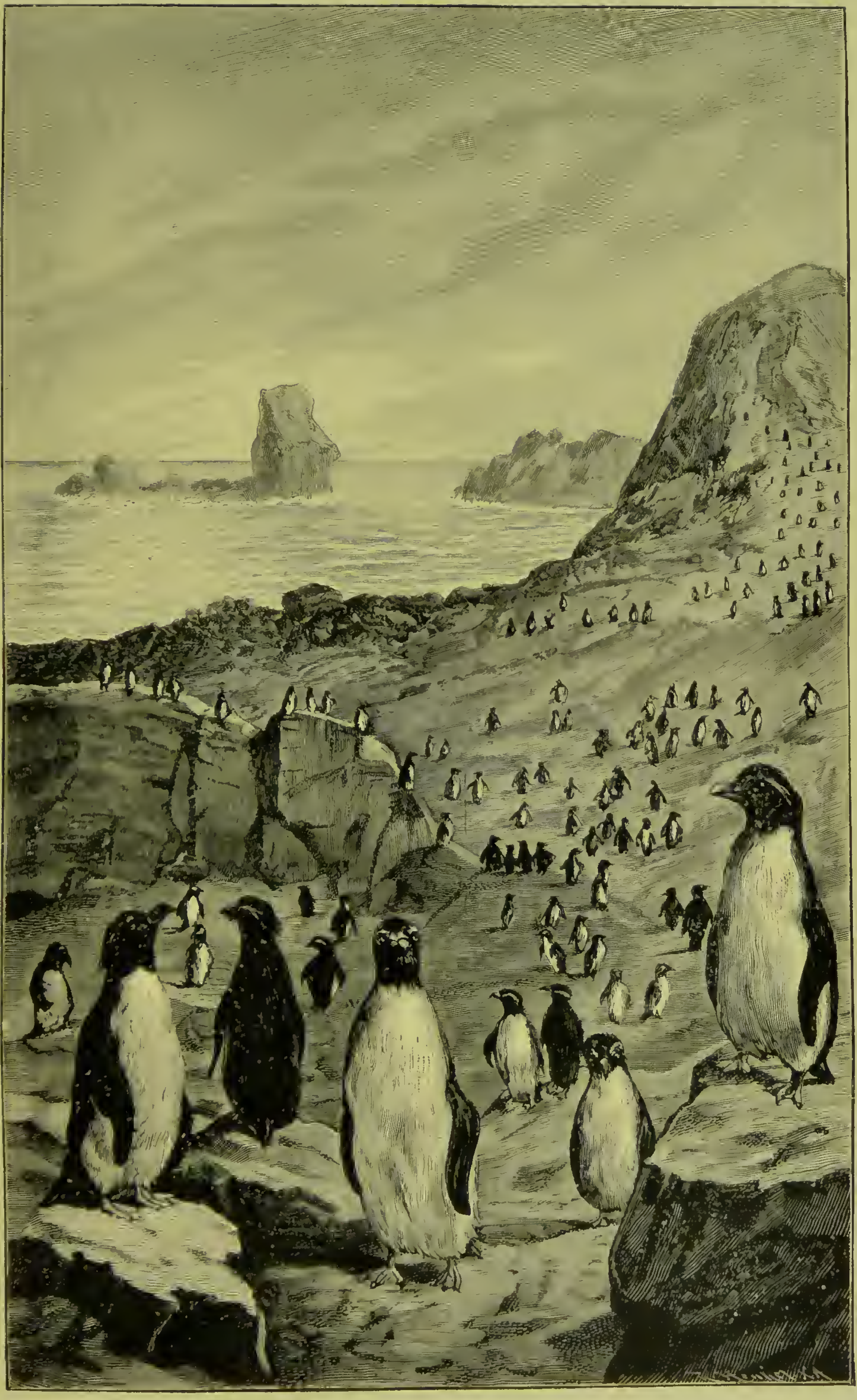
Social Birds (Aves).—Many Birds are eminently social in their habits, and migrant forms may be associated in vast numbers when making their long journeys (see p. 61). But we have yet much to learn regarding the way in which the living together of numerous individuals results in division of labour, or in concerted action. Of two closely related birds the one may

be solitary, and the other markedly gregarious, the Raven and the Rook affording a good instance of this. Each is adapted to its surroundings in a different way, and both adaptations are admirable of their kind, though possibly the social habit gives a better chance in the struggle for existence, and it certainly has a tendency to promote the development of comparatively high mental qualities. As elsewhere remarked (p. 107), the remarkable caste-system which distinguishes social insects has a serious penalty attached to it, for extreme specialization involves a loss of plasticity which, if surroundings change quickly, may mean extinction. But in social Birds and other Vertebrates improved mental powers may be expected to confer increased ability to cope with changing surroundings, and a community of the kind does not suggest a complicated machine easily thrown out of gear, as a nest, say, of Termites, irresistibly does.

As an example of a common social bird we may take the Rook (*Corvus frugilegus*), where there is abundant evidence to show that individuals may render services to the community, and that there may be co-operation to bring about certain common ends. We must, however, receive with caution some of the accounts that have been given of these crafty birds, and which would endow them with almost human attributes. It would appear that when raiding cultivated fields they commonly set sentinels on adjoining trees, and these worthies promptly give warning in raucous tones of the approach of danger in the shape of an agriculturalist. They certainly seem to have acquired knowledge, based on painful experience, of the lethal properties of firearms. Bernard observed Rooks co-operating to hunt field-voles, and his observations are thus summarized by Houssay (in *The Industries of Animals*):—"His curiosity was excited by the way in which numerous rooks stood about a field cawing loudly. In a few days this was explained: the field was covered with rooks; the original assemblage had been calling together a mouse-hunt, which could only be successfully carried out by a large number of birds acting in conjunction. By diligently probing the ground and blocking up the net-work of runs, the voles, one or more at a time, were gradually driven into a corner. The hunt was very successful, and no more voles were seen in that field during the winter." The social nesting-habits of Rooks are familiar to all, for the cheerful sights and sounds of the rookery lend to the country a

CRESTED PENGUINS OR ROCK-HOPPERS
(*Eudyptes chrysocome*)

Penguins are more thoroughly aquatic than any other existing birds, their wings having been converted into paddles of great efficiency, though entirely useless for purposes of flight. The group is characteristic of the Southern Hemisphere, and practically limited to the shores of the Antarctic Ocean. The species represented is the Crested Penguin or Rock-hopper (*Eudyptes chrysocome*), which ranges from the Falkland Islands to New Zealand. It is a handsome black-and-white bird, with an orange-coloured crest on either side of the head. Like so many sea-birds the Rock-hoppers are social in habit. Their favourite breeding-grounds are boulder-strewn slopes at some little distance from the sea, and near fresh water, in which they are fond of bathing. The nest is often a mere hollow scratched in the earth, though stems and leaves may be roughly drawn together to form it. The Rock-hopper, like Penguins generally, broods over its eggs in an erect or semi-erect position, bringing them into contact with a bare patch on the under side of the body, an arrangement which secures a maximum of heat.



CRESTED PENGUINS OR ROCK-HOPPERS (EUDYPTES CHRYSOCOME)
ON THE SHORES OF THE ANTARCTIC OCEAN

charm of their own (fig. 1103). The following vivid account given by Dixon (in *Among the Birds in Northern Shires*) will call up pleasant memories to the minds of many readers:—"And then their home in the cluster of elm-trees yonder is a place fraught with interest if full of noise. Towards the close of February, or, if the weather be still inclement, not until the

Fig. 1103. A Rookery

beginning of March, and at least a fortnight or three weeks later than in Devonshire, the rooks begin to tidy up their big nests in the slender branches at the tree-tops. Others, less fortunate, commence to build entirely new nests. But this building is by no means universal for a week or more; the mania for collecting sticks and turf has not yet spread through the entire colony, and numbers of birds may be seen looking on with indifference at the efforts of more industrious neighbours. What a noisy

animated scene the old rookery is for the next month, until the eggs are laid in the big massive nests; then there is comparative quietness until the young are hatched, when the noisy clamour begins again with greater volume until nestlings and parents get on to the adjoining fields. They return in many cases to the nest trees to roost, and then each evening the din is deafening as troop after troop of tired birds come straggling in from all directions and caw themselves hoarse before dropping off to sleep in the tall trees." The Social Grosbeak has been spoken of in an earlier section as a remarkable example of social nesting-habits (see vol. iii, p. 463).

The social habit is not infrequently conducive to successful defensive measures against enemies. Birds of the swallow kind will unite together to "mob" a hawk that ventures too near their nests, and other instances might easily be given.

Recognition Marks in Birds.—It is obviously advantageous for the members of a community of animals to be able to recognize one another with ease and certainty. They are safer, on the whole, when they keep together, for approaching danger is pretty sure to be perceived by some of them, and these individuals are able to communicate the fact to their fellows. Co-operation in the pursuit of food is also promoted, and, in migrant species, long journeys are more likely to be successfully made in fairly close order.

Wallace has given the name of "recognition marks" to certain colour-arrangements which appear to be of importance in the present connection, and he speaks as follows about the matter (in *Darwinism*).—"Among birds, these recognition marks are especially numerous and suggestive. Species which inhabit open districts are usually protectively coloured; but they generally possess some distinctive markings for the purpose of being easily recognized by their kind, both when at rest and during flight. Such are, the white bands or patches on the breast or belly of many birds, but more especially the head and neck markings in the form of white or black caps, collars, eye-marks, or frontal patches . . . (see fig. 1104). Recognition marks during flight are very important for all birds which congregate in flocks or which migrate together; and it is essential that, while being as conspicuous as possible, the marks shall not interfere with the general protective tints of the species when at rest. Hence they

usually consist of well-contrasted markings on the wings and tail, which are concealed during repose, but become fully visible when the bird takes flight. Such markings are well seen in our four British species of shrikes, each having quite different white marks on the expanded wings and on the tail-feathers; and the same is the case with our three species of Saxicola—the stone-chat, whin-chat, and wheat-ear—which are thus easily recognizable on the wing, especially when seen from above, as they would be by stragglers looking out for their companions. . . . Those birds

Fig. 1104 —1, Lesser Tern (*Sterna minuta*), and 2, Ringed Plover (*Ægialitis hiaticola*)

which are inhabitants of tropical forests, and which need recognition marks that shall be at all times visible among the dense foliage, and not solely or chiefly during flight, have usually small but brilliant patches of colour on the head or neck, often not interfering with the generally protective character of their plumage. Such are the bright patches of blue, red, or yellow by which the usually green Eastern barbets are distinguished; and similar bright patches of colour characterize the separate species of small green fruit-doves. To this necessity for specialization in colour, by which each bird may easily recognize its kind, is probably due that marvellous variety in the peculiar beauties of some groups of birds." If we admit the truth of the view just set forth, it follows that, in many birds, comparatively slight differences in plumage will often prove a safe guide in the discrimination of species. Though trivial in themselves they may nevertheless

be regarded as natural "labels", which indicate the presence of other specific differences that may be much more difficult to detect. The theory of recognition marks is strongly supported by the fact that animals which turn white in winter commonly do not do so completely, but retain small dark patches. The Ptarmigan (*Lagopus mutus*, fig. 1105), for example, retains black markings on the side of the tail, while the male in winter plumage is further distinguished by black streaks near the eye.

Social Mammals (Mammalia).—A large number of mammals affect the gregarious habit, and some examples of the benefits

Fig. 1105.—Male Ptarmigan (*Lagopus mutus*) in Winter Plumage

accruing have elsewhere been given. Wolves, for example, hunt in packs, and sometimes secure their prey by very ingenious devices (see vol. ii, p. 16). The herding together of various Hoofed Mammals is distinctly of advantage in defence, and many such forms post sentinels to warn them of approaching danger (see vol. ii, p. 365). Troops of Baboons and Monkeys make well-organized raids, while their tactics during retreat from foes are often decidedly skilful, and have reference to the well-being of the community (see vol. ii, p. 363). The cubs of the Fur-Seal benefit by the mode of life in their "rookery" (see vol. iii, p. 492). To consider in detail all the groups of mammals in regard to social habits would be an almost endless task, and the present purpose will perhaps be sufficiently served by taking one or two typical and interesting cases.

PRAIRIE DOGS (*Cynomys Ludovicianus*)

These animals have received their somewhat inappropriate name from the curious way in which they "bark" on the approach of danger, but in reality there is nothing dog-like about them, for they are social burrowing Rodents or Gnawing Mammals, not distantly allied to the Marmots of the Old World. They are among the most characteristic inhabitants of the great plains to the east of the Rocky Mountain Highland in North America. The earth thrown out from each burrow is heaped up into a mound that serves as a sort of watch-tower, on which a sentry may be posted.

The Rattlesnake or the Burrowing Owl may take possession of a burrow, but the old idea that snake, bird, and prairie-dog live together in the same quarters on amicable terms is quite untenable.

PRAIRIE DOGS (CYNOMYS LUDOVICIANUS) AT HOME

The Common Prairie-Marmot (*Cynomys Ludovicianus*), more familiarly known as the Prairie-"Dog", on account of the barking sound to which it gives utterance when alarmed, is a social burrowing rodent native to the dry open plains on the east of the Rocky Mountain highland. Several individuals live together in the same burrow, and a very large number of these homes may be associated together into a "city". The excavated earth is partly heaped up into a mound at the entrance to the burrow, and this may almost be called a watch-tower, since it is commonly occupied by a sentinel, who performs the usual duties of his office. On hearing his warning bark the neighbouring individuals scuttle down into their underground dwellings. The opening of each burrow is somewhat funnel-shaped, some of the earth dug out having been regularly arranged round it, and pressed together till firm: the use probably being to prevent flooding out during sudden showers. Owing to the fact that Burrowing Owls and Rattlesnakes are not infrequently found in the dwellings of this rodent, the conclusion has somewhat hastily been drawn that the three kinds of animal constitute a kind of "happy family", living together on the best of terms. This, however, is not the case, for the Owl simply takes possession of a deserted burrow, while the Rattlesnake appropriates one at random, ejecting the rightful owner if necessary, and thereafter visits his neighbours, levying a tax upon their offspring. The Common Prairie-Marmot is about a foot in length, exclusive of the short tail, but a larger and a smaller species are also indigenous to North America. The former is the Mexican Prairie-Marmot (*C. Mexicanus*), while the smaller sort is the Columbian Prairie-Marmot (*C. Columbianus*), which inhabits higher ground in the western part of North America. Their habits are much the same as those of the common form. It appears that there is a winter-sleep in the case of individuals which live pretty far north. The True Marmots (species of *Arctomys*) are somewhat larger animals allied to the preceding, and like them gregarious burrowers. They have a wide range through the northern parts of North America and Eurasia, living on plains except in the southern part of their distributional area, where they are typical mountain-animals. It is a familiar fact that they indulge in a long winter-sleep.

The Beaver (*Castor fiber*) is a very large social Rodent which formerly had a wide extension in Europe and North America,

but has been hunted down to such a deplorable extent, chiefly for the sake of its fur, that it now exists in greatly diminished numbers, and in all probability will become extinct at no distant period, except in cases where it is strictly preserved. It was once a native of Great Britain, though its range never extended to Ireland. According to Geraldus Cambrensis it lived in the river Teifi (Cardiganshire) so late as 1188, and is thought to have survived in Scotland to a still later period. The American Beaver is probably a distinct species (*C. Canadensis*), and its habits have been more carefully studied than those of the European kind. The animal is an expert swimmer and diver, being modified in structure in connection with this habit, as elsewhere described (see vol. iii, p. 73). In all probability it was originally a bank-dweller, excavating an upwardly sloping burrow, with the top end expanded into a living chamber, and the entrance below the surface of the water. And where this unfortunate animal is subjected to much persecution its architectural efforts do not attain anything of more elaborate nature. Under normal circumstances, however, much more complex homes are made, which may be regarded as having been evolved by gradual stages from the primeval burrow. They involve the construction of "dams" and "lodges", a narrow stream being converted by the former into a series of ponds, of which the surface-level remains fairly steady, thus giving favourable conditions for building the lodges or houses. It is essential that the district should be well wooded, as the chief material used in making the dams consists of the trunks and branches of trees, some of which may be as much as 40 inches round at the base and 120 feet high. The tools employed are the powerful incisor teeth, and a tree is felled by being bitten round in a neat manner near the ground. As H. T. Martin says (in *Castorologia*):—"No better work could be accomplished by a most highly-finished steel cutting tool, wielded by a muscular human arm".

Trees growing near water usually slant towards it, and when sufficiently weakened by the gnawing process must, as a rule, fall that way. It was once supposed that the Beaver secured this end by biting more wood from the side facing the stream, but this appears to be incorrect. When the tree is felled its branches are gnawed off, and the timber is cut up into lengths of five or six feet, the bark being peeled off to serve as food. It is, indeed,

quite possible that the habit of bark-feeding was the original one, and that the use of the wood for constructive purposes has been evolved subsequently. The process described provides for the framework of a dyke, and twigs, &c., are added, together with much earth. The nature of the work is adapted to the local conditions: in the case of brooks or large streams with ill-marked banks there is a "stick-dam", in which the earth is of comparatively small amount; where the water is deeper and the banks clearly defined there is a "solid-bank dam", with enough earth to cover up all the woody framework. In the former case no special channel is made through which the water may make its way, while in the latter case a suitable exit is scooped out on the top of the dyke. In order the better to resist water-pressure, the upper side of the barrier is sloping; its lower surface is approximately vertical. The foundation is from about 9 to 12 feet, the upper part about 2 feet in thickness. The dam is built straight across if the current is gentle, while the greater pressure existing in a rapid stream is compensated by making the work curved, with its convex side facing upwards. The following careful account of this preliminary engineering work is given by Lewis H. Morgan (in *The American Beaver and his Works*), and it will be noted that he does not favour the common view that several or a large number of families co-operate for the benefit of the "village":—"The dam is the principal structure of the beaver. It is also the most important of his erections as it is the most extensive, and because its production and preservation could only be accomplished by patient and long-continued labour. In point of time, also, it precedes the lodge, since the floor of the latter and the entrances to its chamber are constructed with reference to the level of the water in the pond. The object of the dam is the formation of an artificial pond, the principal use of which is the refuge it affords to them when assailed, and the water connection it gives to their lodges and to their burrows in the banks. Hence, as the level of the pond must, in all cases, rise from one to two feet above these entrances for the protection of the animal from pursuit and capture, the surface-level of the pond must, to a greater or less extent, be subject to their immediate control. As the dam is not an absolute necessity to the beaver for the maintenance of his life, his normal habitation being rather natural ponds and rivers, and

burrows in their banks, it is, in itself considered, a remarkable fact that he should have voluntarily transferred himself, by means of dams and ponds of his own construction, from a natural to an artificial mode of life. Some of these dams are so extensive as to forbid the supposition that they were the exclusive work of a single pair, or of a single family of beavers; but it does not follow, as has very generally been supposed, that several families, or a colony, unite for the joint construction of a dam. After careful examination of some hundreds of these structures, and of the lodges and burrows attached to many of them, I am altogether satisfied that the larger dams were not the joint product of the labour of large numbers of beavers working together, and brought thus to immediate completion; but, on the contrary, that they arose from small beginnings, and were built upon year after year, until they finally reached that size which exhausted the capabilities of the location; after which they were maintained for centuries, at the ascertained standard, by constant repairs. So far as my observations have enabled me to form an opinion, I think they were usually, if not invariably, commenced by a single pair, or a single family, of beavers; and that when, in the course of time, by the gradual increase of the dam, the pond had become sufficiently enlarged to accommodate more families than one, other families took up their residence upon it, and afterwards contributed by their labour to its maintenance. There is no satisfactory evidence that the American beavers either live or work in colonies; and if some such cases have been observed, it will either be found to be an exception to the general rule, or in consequence of the sudden destruction of a work upon the maintenance of which a number of families were depending. The great age of the larger dams is shown by their size, by the large amount of solid materials they contain, and by the destruction of the primitive forest within the area of the ponds; and also by the extent of the beaver-meadows all along the margins of the streams where dams are maintained, and by the hummocks formed upon them by and through the annual growth and decay of vegetation in separate hills. These meadows were undoubtedly covered with trees adapted to a wet soil when the dams were constructed. It must have required long periods of time to destroy every vestige of the ancient forest by the increased saturation of the

earth, accompanied with occasional overflows from the stream. The evidence from these and other sources tends to show that these dams have existed in the same places for hundreds and thousands of years, and that they have been maintained by a system of continued repairs.

"At the place selected for the construction of a dam the ground is usually firm and often stony, and when across the channel of a flowing stream, a hard rather than a soft bottom is preferred. Such places are necessarily unfavourable for the insertion of stakes in the ground, if such were, in fact, their practice in building dams. The theory upon which beaver-dams are constructed is perfectly simple, and involves no such necessity. Soft earth, intermixed with vegetable fibre, is used to form an embankment, with sticks, brush, and poles imbedded within these materials to bind them together, and to impart to them the requisite solidity to resist the effects both of pressure and of saturation. Small sticks and brush are used, in the first instance, with mud and earth and stones for down-weight. Consequently these dams are extremely rude at their first commencement, and they do not attain their remarkably artistic appearance until they have been raised to a considerable height, and have been maintained by a system of annual repairs for a number of years."

The beaver-house or "lodge" is a domed structure, constructed of clay and wood on the upper side of the dam. A lodge is from 6 to 8 feet high, and its base is 9 to 12 feet broad, or rather more. The living-room within, which also serves as a "nursery", is lined with grass, and its floor is at water-level. There are several entrances which open well below the surface, so that there is no danger of blockage by ice during the winter. The beaver does not hibernate, and its pond is deep enough to enable it to swim about under the surface of the ice in the most rigorous seasons. The lodge includes a store-chamber, in which large quantities of the succulent rhizomes of certain water-lilies are heaped up for winter use. Tree-branches are also accumulated in the deeper parts of the pond for the same purpose. Martin (in *Castorologia*) makes the following interesting remarks regarding the popular misconception as to the highly-finished character of the lodge, and also as to the way in which it has evolved from the simple burrow:—"The beaver-lodge is generally included in the list of marvels reserved for the investigation

of those who visit beaver-districts, and yet no greater disappointment awaits the inquirer than the first inspection of one. Somehow the minds of all lovers of natural history become affected by the fabulous accounts concerning this structure, and it is a shock to stand for the first time before a pile of twigs, branches, and logs, heaped in disorder upon a small dome of mud, and to learn that this constitutes the famous lodge. Of course the superficial glance does not convey all that can be learnt in connection with this work, but it does most completely disillusionize the mind. On breaking through the upper walls, the interior is found to be similar to the general type of an animal's sleeping apartment, and has scarcely any distinguishing characteristic. . . . Starting with the simple burrow, the next step is the accumulation of logs and branches about its entrance, forming what is called a 'bank-lodge'. In places where the water is shallow towards the shore, a great advantage would be derived from extending this artificial covering of brushwood, so that in time a natural evolution of the lodge disconnected entirely from the shore would take place, and form an independent and very convenient refuge from landward enemies." It may be well to add that the large flattened tail of the beaver is a swimming organ, and is not employed as a trowel. Clay is manipulated entirely by means of the fore-paws.

Recognition Marks and Odours.—Many of the gregarious Mammals possess contrasted light and dark markings which possibly enable the individuals of the same species to recognize one another, as in the similar cases already described for birds (p. 132). The most familiar instance is the white patch on the under side of a Rabbit's tail, which, though it does not interfere with the general protective character of the coloration, makes the animal easily seen when it moves rapidly. On this account it has also been described as an illustration of "signalling coloration", by which, when retreating from danger, an unconscious warning is given by the animal to its fellows. Other instances cited by Wallace (in *Darwinism*) are antelopes (fig. 1106), zebras, monkeys, and lemurs. In regard to the first of these, he suggests that the great variety in the shape of the horns has to do with recognition.

Gregarious Mammals are commonly distinguished by the possession of a keen sense of smell, which has various relations to habits. In herbivorous forms, for instance, it is of great

importance with reference to detecting the approach of carnivores. But it would also seem to play a part in facilitating mutual recognition between individuals of the same kind. At any rate we often find that social forms are provided, in various parts of the body, with peculiar glands, the secretions of which emit

Fig. 1106.—Hartebeest (*Bubalis caama*)

characteristic odours, often, to us, of disagreeable kind. The Rabbit (*Lepus cuniculus*) is a case in point, for its "rabbity smell" is due to the products of a pair of glands (perineal glands) in the hinder part of the body. The little Peccaries (*Dicotyles*) of South America possess a good-sized gland under the skin of the back, the secretion being here a stinking oily fluid, the emanations from which no doubt assist in keeping the members of a troop together.

There is good reason why they should, for, as Beddard says (in *The Cambridge Natural History*), "they owe, too, their safety from many foes to their sociable habits. Being nocturnal animals they are liable to the attacks of the jaguar, which will speedily overpower and devour a peccary that has strayed from its herd."

In Deer there is usually a scent-gland (the *crumen*) opening into a pit below the eye; so also in most Antelopes. The latter may also possess other scent-glands in the groin or between the toes. Bottle-shaped structures of the sort are found between the digits in Sheep (fig. 1107). It is interesting to note that a captive specimen of the Klipspringer Antelope (*Oreotragus saltator*) has been observed to deliberately deposit upon various objects the secretion that oozes out under its eyes. Such a habit if practised under natural conditions would no doubt help these animals to find one another. But the glands in the feet of Sheep, &c., are of special interest here, for drops of the strong-smelling secretion must constantly be squeezed out on to the ground, leaving a well-marked "trail".

Fig. 1107.—Foot of Sheep (*Ovis aries*) dissected to show scent-gland, the opening of which is indicated by an arrow

Many other examples of scent-glands might easily be given. The exact use no doubt varies in different cases, and may have nothing to do with the social habit proper. For example, an animal may thus be assisted in the search for a mate, and Beddard suggests that some scents are possibly of mimetic nature. The odour of the Musk-Deer is perhaps of this kind, for it may suggest to aggressors the musky smell of the Crocodile, an animal which they would think twice before attacking. Stink-glands as a direct defence have been spoken of elsewhere (see vol. ii, p. 301).

CHAPTER LXIV

ASSOCIATION OF ORGANISMS—COURTSHIP AND MATING

It is well known that among a number of savage tribes well-developed thews and sinews are an invaluable possession to a young man inclined towards matrimony; he has, in short, to fight for a wife. Among civilized human communities good looks play no unimportant part in the matter, though financial considerations are sometimes said to be paramount. We have, in fact, the Law of Battle and the Law of Beauty, both very clearly enunciated by Darwin in the case of animals, and illustrated by a wealth of fact. The former law is admitted by all to have great influence in many cases in deciding which individuals shall mate together, but Wallace, whose opinion in all zoological matters is entitled to the greatest respect, does not think that ornamental males are preferred as partners by those of the opposite sex. The part of his argument, so far as the human species is concerned, is thus expressed (in *Darwinism*):—"A young man, when courting, brushes or curls his hair, and has his moustache, beard, or whiskers in perfect order, and no doubt his sweetheart admires them; but this does not prove that she marries him on account of these ornaments, still less that hair, beard, whiskers, and moustache were developed by the continued preferences of the female sex. So, a girl likes to see her lover well and fashionably dressed, and he always dresses as well as he can when he visits her; but we cannot conclude from this that the whole series of male costumes, from the brilliantly-coloured, puffed, and slashed doublet and hose of the Elizabethan period, through the gorgeous coats, long waist-coats, and pigtails of the early Georgian era, down to the funereal dress-suit of the present day, are the direct result of female preference." One is inclined to believe, however, that an average girl does prefer a good-looking young man, and that female preference has had a directive influence on the evolution of male

attire. And there are so many facts supporting the view that the females of many animals are influenced by the ornamental endowments of prospective partners, that the existence of the Law of Beauty will be here taken as provisionally proved. At the same time it must not be applied to explain facts in too sweeping a manner. Every case should be considered on its own merits, and our knowledge of animal habits is so very imperfect that it is easy to fall into error. It is also necessary to carefully avoid the pitfall of unconsciously assuming that the mental endowments of lower animals closely resemble our own. There is no reason to think, for example, that a hen-bird exerts a deliberate choice in the selection of a mate. She may be strongly attracted towards one of several possible partners, and beauty of plumage or voice may have to do with such attraction, but that is not the same thing as "deliberate choice" in the usual sense.

It is only among comparatively specialized animals that the Laws of Battle and Beauty are exemplified, and a few examples will fittingly illustrate the subject.

COURTSHIP AND MATING OF MAMMALS (MAMMALIA)

THE LAW OF BATTLE.—A complete list of species in which the males fight in order to secure mates would be a fairly complete catalogue of Mammals, for in this class the question of Beauty would appear to be subordinate. One would naturally expect combats to be most frequent in cases where the females were comparatively few in number, but as a matter of fact it is better marked among polygamous species, which are necessarily social, though it by no means follows that all gregarious animals are polygamous. Deer and various other Hoofed Mammals afford good illustrations, and as these lead a wandering life it is possible that the practice of polygamy has arisen from the desirability of keeping a herd together, an end to which it is more favourable than monogamy. In nearly all species of Deer the males alone possess antlers, and this is correlated with the fact that they fight furiously together in the struggle to secure mates. In the case of our native Red Deer (*Cervus elaphus*) the adult stags live by themselves except for about three weeks in the autumn, this being the mating-season. Fierce combats are then frequent, that result in the discomfiture of the weaker males, some of which may be

killed outright. Every victor is able to secure a number of partners, but he has to be continually on the look-out to repel other stags wishing to interfere with his family life, and may have to yield his privileges to an intruder. Might as usual is the only right.

THE LAW OF BEAUTY.—Adult male Mammals are not infrequently distinguished from those of the other sex by the possession

Fig. 1108.—Male Mandrill (*Papio mormon*)

of various ornaments, among which may be mentioned the mane of the Lion and the beard of the Goat. An extreme case is presented by the West African Baboon known as the Mandrill (*Papio mormon*, fig. 1108), the name of which probably means "man-like baboon". If so, it is rather a libel upon the human species, for the appearance of the adult male is decidedly startling. Either side of the face presents a furrowed blue swelling, the grooves being purple, while between these ornaments is a strip of bright red, passing down to the end of the nose, which is of the same lively hue. A pointed beard of orange yellow completes a scheme of colour that is effective in its way. The large bare

patches on the hinder part of the body are also of a vivid scarlet, with a tinge of blue. The teeth are of formidable nature, as in many apes and monkeys, the canines being particularly large, partly no doubt with reference to defence, but partly also in relation to combats with other males of the same species. The female Mandrill is faded-looking in comparison to her mate. The swellings on her face are comparatively small and pale, while there is never more than a faint display of red.

The attractions of male mammals often include a relatively well-developed voice, as in the Red Deer, where during the mating season the stag makes a characteristic roaring sound, known as "belling", though whether this serves any special purpose is doubtful. The last remark also applies, it would seem, to the American Howling Monkeys, regarding one of which Darwin thus speaks (in *The Descent of Man*):—"The vocal organs of the American *Mycetes caraya* are one-third larger in the male than in the female, and are wonderfully powerful. These monkeys in warm weather make the forests resound at morning and evening with their overwhelming voices. The males begin the dreadful concert, and often continue it during many hours, the females sometimes joining in with their less powerful voices. An excellent observer, Rengger, could not perceive that they were excited to begin by any special cause; he thinks that, like many birds, they delight in their own music, and try to excel each other." One is irresistibly reminded here of the "dreadful concerts" held nightly by the common Cat. The males appear to take the leading parts, and their unearthly cries seem to express defiance of one another, rather than to be a means of attracting the softer sex.

COURTSHIP AND MATING OF BIRDS (Aves)

The Law of Battle.—Most male birds are exceedingly pugnacious, fighting for the possession of mates in the most determined manner, the habit being perhaps best-marked in the polygamous species. They may be provided with special weapons, the spurs of cocks being a familiar example. The methods of fighting of some birds are described as follows by Brehm (in *From North Pole to Equator*):—" Rival ostriches fight with their strong legs, and, striking forwards, tear deep wounds with their sharp toe-nails in the breast, body, and legs of their

opponent. Jealous bustards, after spending a long time challenging each other with throat inflated, wings and tail outspread, and much grumbling and hissing, make use of their bills with very considerable effect. Sand-pipers and other shore-birds, particularly the fighting ruffs, which fight about everything, about

Fig. 1109.—Cock Chaffinches Fighting

a mate or about a fly, about sun and light, or about their standing-ground, run against each other with bills like poised lances, and receive the thrusts among the breast feathers, which in the case of the ruffs are developed into what serves as a shield [much as in the Lion]. Coots rush at each other on an unsteady surface of water-plants, and strike each other with their legs. Swans, geese, and ducks chase each other till one of the combatants

succeeds in seizing the other by the head and holding him under water, till he is in danger of suffocating, or at least until he is so much exhausted that he is unable to continue the struggle."

A battle-royal between two cock chaffinches is represented in fig. 1109.

THE LAW OF BEAUTY.—It is familiar to all that male birds very often differ markedly from the females in the possession of more ornamental characters, and a more powerful or more beautiful voice. And it is significant that their charms are in full perfection at the time of mating. The contrast between the sexes is obvious on looking round any poultry-yard. Among ordinary fowls the striking plumage of the cock, and his scarlet wattles and comb, make him a handsome bird by contrast with the rather dowdy hen. The drake is distinctly handsomer than the duck. But such examples are far excelled by some of the allies of domesticated fowls, for in many of these the plumage of the male is beautiful beyond mere verbal description. Such in particular are the Golden Pheasant (*Chrysolophus pictus*), Amherst's Pheasant (*C. Amherstiæ*), the Argus Pheasant (*Argusianus giganteus*), and the Peacock (*Pavo cristatus*). Gorgeously decorated male birds of the sort display their charms during courtship in a remarkable manner. We may take as an example the Scarlet Tragopan (*Tragopan satura*), of which the following description by Ogilvie Grant (in *The Royal Natural History*) will convey some idea of the brilliancy of the colour-scheme:—"The male has the top and sides of the head black, the neck, mantle, and under-parts orange-carmine, and the rest of the upper parts olive-brown, each feather being ornamented at the tip with a round white spot, partially or entirely margined with black; the outer wing-coverts being edged on each side with dark orange-carmine. The throat-wattle is salmon-colour with transverse blue bars, and the legs are pale flesh." Brehm, after describing the love-dances of various birds, thus speaks (in *From North Pole to Equator*) of this particular form:—"More remarkable than all the rest is the behaviour of the male tragopans or horned pheasants of Southern Asia, magnificently decorative birds, distinguished by two brightly-coloured horn-like tubes of skin on the sides of the head, and by brilliantly-coloured extensible wattles. After the cock has walked round the hen several times without appearing to pay any attention to her, he stands still at

COURTING OF THE TRAGOPAN (*Ceriornis satyrus*)

Among highly organized groups of animals the male is commonly more beautiful than his partner, and the matrimonial chances of the former are supposed to be often proportionate to his decorative endowments. According to this view the æsthetic taste of females has had an important influence in the evolution of male adornments. The Horned Pheasant (*Ceriornis satyrus*) or Tragopan of Northern India, which is one of a small group of extremely handsome species, affords a good illustration of the striking difference in appearance which often distinguishes the sexes. As will be gathered from the plate, the hen-bird (in the foreground) is comparatively dowdy, but the cock possesses adornments of no common order, which he is represented as fully displaying with a view of securing the favour of a desired partner. His ornaments include a couple of blue outgrowths on the head, which can be made to stick up like horns, and a pair of brilliantly coloured wattles capable of inflation to form a sort of horseshoe-shaped collar. Details of the colour-scheme and of the love-antics are given in the text.

THE HORNED PHEASANT (CERIORNIS SATYRUS) OR TRAGOPAN OF NORTHERN INDIA

a particular spot, and begins to bow. More and more quickly the courtesies follow each other, the horns meantime swelling and tossing, the wattles dilating and collapsing again, till all are literally flying about the head of the love-crazed bird. Now he unfolds and spreads his wings, rounds and droops his tail, sinks down with bent feet, and, spitting and hissing, lets his wings sweep along the ground. Suddenly every movement ceases. Bent low, his plumage ruffled, his wings and tail pressed against the ground, his eyes closed, his breathing audible, he remains for a while in motionless ecstasy. His fully unfolded decorations gleam with dazzling brightness. Abruptly he rises again, spits and hisses, trembles, smooths his feathers, scratches, throws up his tail, flaps his wings, jerks himself up to his full height, rushes upon the female, and, suddenly checking his wild career, appears before her in olympic majesty, stands still for a moment, trembles, twitches, hisses, and all at once lets all his glory vanish, smooths his feathers, draws in his horns and wattles, and goes about his business as if nothing had happened."

The combination of "spitting and hissing" with "olympic majesty" in the tragopan strikes one as somewhat lacking in dramatic fitness, from the human stand-point, but it serves as a reminder that the most gorgeously decorated male birds are not remarkable for beautiful voices. The unpleasant scream of the Peacock is no doubt familiar to all. On the other hand, the most gifted songsters are often modestly attired, and it is further to be noted that birds of small size are particularly notable in the matter of vocal attainments. In some cases, at any rate, love-songs would appear to prove more attractive to the female than elaborate colour-displays or amorous antics. On this point Darwin makes the following remarks (in *The Descent of Man*):—

"Naturalists are much divided with respect to the object of the singing of birds. Few more careful observers ever lived than Montagu, and he maintained that the 'males of song-birds and of many others do not in general search for the female, but, on the contrary, their business in the spring is to perch on some conspicuous spot, breathing out their full and amorous notes, which, by instinct, the female knows, and repairs to the spot to choose her mate'. Mr. Jenner Weir informs me that this is certainly the case with the nightingale. Bechstein, who kept birds during his whole life, asserts 'that the female canary

always chooses the best singer, and that in a state of nature the female finch selects that male out of a hundred whose notes please her most'. There can be no doubt that birds closely attend to each other's song." It seems, however, to be certain that birds take a delight in their musical powers quite apart from the question of courtship, often singing from emulation or from sheer "joy of life".

Fig. 1110.—Male Australian Bustard (*Otis australis*), with Throat-pouch inflated

It is almost superfluous to remark that in appraising the attractions of male birds we must remember that what to us is merely comical, may nevertheless be well adapted to its purpose. In the Common Bustard (*Otis tarda*), for instance, the male indulges in strange antics and displays of plumage, and often possesses a large pouch that can be dilated to serve as a resonator, no doubt making the love-call more sonorous, though this is no more than the syllable "oak" often repeated. The Australian Bustard (*Otis australis*, fig. 1110) also has such a pouch, which in this case is simply a greatly dilatable part of the gullet.

Odorous attractions are sometimes possessed by the male, as in the Musk-Duck (*Cairina moschata*), a species which ranges from Mexico to the Argentine Republic, and is known in captivity by the erroneous name of "Muscovy"-Duck.

It must not be imagined that the courtship of any particular species necessarily exemplifies the Law of Battle or the Law of Beauty only, for in many cases strength and æsthetic qualities are both called into play.

COURTSHIP AND MATING OF REPTILES (Reptilia).

The Law of Battle.—Some male Reptiles engage in combats with one another during the mating season, a habit which has been observed in Alligators, some Tortoises, and certain

Fig. 1111.—Owen's Chameleon (*Chamæleo Oweni*). Female on left; male on right

Lizards. Among the latter the males may be provided with strong spines or horns on the head, especially so in some of the Chameleons (fig. 1111), and these weapons are no doubt used in their fights with one another. The jealous ferocity of the American Alligator (*Alligator Mississippiensis*) is thus graphically touched off by Cyrus W. Butler (in *Big Game of North America*):—"On the whole, he is a sluggish, very sluggish, animal, not even being an active hunter; but loafs around in hope that something may turn up—that probably a fish may unwittingly swim near enough to be snapped up by a quick motion of his long jaws. But lazy and sluggish as he is, and cold as is his blood, there are times when it must course swiftly through his veins; for on a little island of muck, in the centre of a pond, a female

is heaping up a pile of saw-grass and dirt for a nest, while upon opposite sides of the pond, and just upon the edge of the saw-grass, eyeing her with warm glances of admiration, and each other with the sullen glare of hatred, lie two old males, whose scarred and bleeding bodies testify that even a 'gator's cold blood is thicker than water. The smaller one moves painfully, for his right fore-foot is missing — the larger one got his jaws upon it, a few rapid turns, and the foot was gone, probably soon buried in the stomach of the victor. The loss of a foot in fighting is quite common, for I have taken three thus maimed, and heard of others."

The Law of Beauty.—The most striking examples among Reptiles of relatively ornamental males is afforded by some of

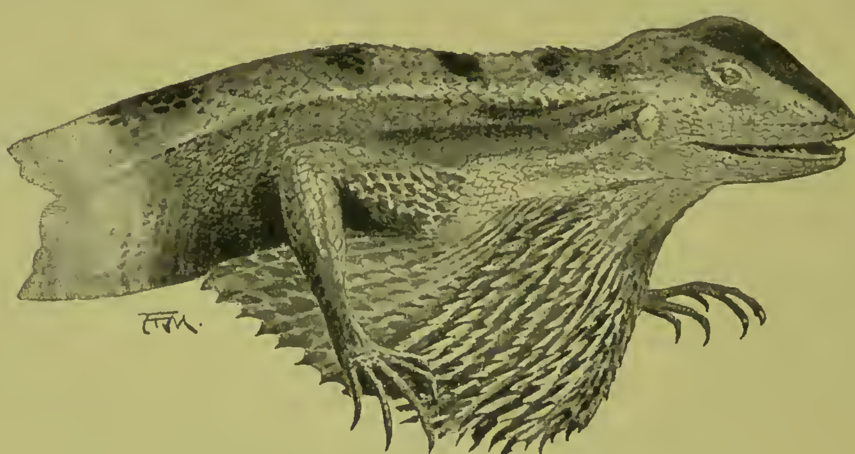


Fig. 1112.—Male Lizard (*Sitana*) with Throat-pouch

the Lizards. In certain Indian species of the genus Sitana (fig. 1112), for instance, the male is provided with a brilliantly-coloured throat-pouch, which can be either folded up or dilated, and is only fully displayed during the mating-season. It also appears that at this time the scent-glands of Crocodiles, Snakes, and Lizards are particularly active in the male.

COURTSHIP AND MATING OF AMPHIBIANS (Amphibia)

The Law of Battle.—Our information here is somewhat scanty, but male Frogs have been observed fighting together with great ferocity during the mating season, at which time also male Toads wrestle with one another in a determined manner, discomfited athletes being at a discount among the females.

The Law of Beauty.—Here we may take as an example

the Great Crested Newt (*Molge cristatus*, fig. 1113), which is one of our few native forms. During the time of courtship the male possesses a special adornment in the form of a high saw-edged crest on the upper side of his body and tail, besides which his colours are brighter than those of the other sex.

The vocal attractions of male Frogs are often considerable. In the Edible Frog (*Rana esculenta*), for instance, the male possesses a pair of croaking sacs at the corners of the mouth, which can be dilated to serve as resonators, imparting a mellow tone to his voice. The "concerts" of this and other species

Fig. 1113.—Great Crested Newt (*Molge cristatus*). Male above; female below

are as striking in their way as the musical efforts of Howling Monkeys and some other Mammals. The following picturesque account of an evening performance of the kind is given by Thoreau (in *Walden*):—"In the meantime all the shore rang with the trump of bull-frogs, the sturdy spirits of ancient wine-bibbers and wassailers, still unrepentant, trying to sing a catch in their Stygian lake,—if the Walden nymphs will pardon the comparison, for though there are almost no weeds, there are frogs there,—who would fain keep up the hilarious rules of their old festal tables, though their voices have waxed hoarse and solemnly grave, mocking at mirth, and the wine has lost its flavour, and become only liquor to distend their paunches, and sweet intoxication never comes to drown the memory of the past, but mere saturation and water-loggedness and disten-

tion. The most aldermanic, with his chin upon a heart-leaf, which serves for a napkin to his drooling chaps, under this northern shore quaffs a deep draught of the once-scorned water, and passes round a cup with the ejaculation *tr-r-r-oonk*, *tr-r-r-oonk*, *tr-r-r-oonk!* and straightway comes over the water from some distant cove the same pass-word repeated, where the next in seniority and girth has gulped down to his mark; and when this observance has made the circuit of the shores, then ejaculates the master of ceremonies, with satisfaction, *tr-r-r-oonk*, and each in his turn repeats the same down to the least distended, leakiest, and flabbiest-paunched, that there be no mistake; and then the bowl goes round again and again, until the sun disperses the morning mist, and only the patriarch is not under the pond, but vainly bellowing *troonk* from time to time, and pausing for a reply."

COURTSHIP AND MATING OF FISHES (Pisces)

The Law of Battle.—During the spawning-season a number of male fishes are very pugnacious, fighting one another on the least provocation. We may take as examples the Salmon (*Salmo salar*) and Three-Spined Stickleback (*Gasterosteus aculeatus*). At the time when Salmon make their annual ascent of rivers the lower jaw of the mature male grows out into a sort of hook (fig. 1114), which is supposed to serve as a protection against the furious charges of his rivals, while at the same time his teeth become long and sharp, being frequently over half an inch in length. Two males have been observed fighting together a whole day, and the mortality is often considerable.

The little Stickleback is no less savage during the days of courtship, at which time he becomes of a vivid red colour, that has earned him the local name of "robin". Fred Smith (in *The Boyhood of a Naturalist*) thus graphically describes a combat:—"Oh, we needn't be so cautious in approaching, at least not this ditch, for the stickleback is monarch of all he surveys here; and though just a bit scared when our shadows fall athwart the water, he immediately reappears in a defiant attitude which there is no mistaking. I speak of 'he', because the only stickleback at present visible, and which I knew

I should find at the spot, is an acquaintance of quite long standing, and is a 'robin', *i.e.* a gentleman stickleback, as beautiful as he is brave. Now see him turn over and show himself when I drop in this little red worm—there, what a gorgeous crimson breast, with sides of brightest silver, and back like the sheen of a sunset sky, and eyes like points of living light! All this, in his efforts to master the poor worm's wriggling, or to break it in two before attempting to swallow. And now that is accomplished, he takes his stand under that dense clump of weed [which contains his nest]. And here comes another stickleback,

Fig. 1114.—Head of Adult Male Salmon (*Salmo salar*), showing hooked lower jaw

innocently looking for something to eat, and approaches within a foot of that clump of weed. Like a lightning flash the 'robin' shoots himself at the intruder, and she, a lady stickleback, turns one or two somersaults, goes very pale and almost transparent, and beats a precipitate retreat. This looks cruel, but he only meant to frighten the brazen female who dared to venture so near to his domain. See him now. Another 'robin' has approached, perhaps the husband of the frightened lady. Now it is war; now he is ready to be cruel if he can. Before we can think, green and crimson and golden lights play madly before our eyes; and this brilliant display is all that can be made out till it is suddenly resolved into two gorgeous robins, more brilliant than ever in their rage, their eyes very balls of fire, their dorsal and lateral prickles erect, and red as though touched with fire. Only an instant are they quiet, when our older friend renews the attack with such ferocity that our later acquaintance deems

discretion the better part of valour, and, not in too great a hurry, but with a certain dignity, follows his lady-love, to whom he no doubt describes the tremendous thrashing he has given to her ungallant molester." Lloyd Morgan (in *Animal Sketches*) gives the following very interesting account of a complete stickleback love-story, the scene being an aquarium:—"I began by putting into one of my glass tanks, in which there grew sufficient healthy weed to ensure the purity of the water, a male Thornie and three females. The male was just beginning to assume the bright colours (blue and crimson and creamy white) of courtship. But the largest and stoutest of the females bullied him so unmercifully — reversing the usual order of things *among sticklebacks*—that in two days he was utterly dejected and crestfallen, and had completely lost all sign of colour. I then put into the same tank another male. Him, too, the irascible old lady bullied unmercifully, pulling his fins and his tail in the most vulgar fashion, until he leapt out of the water in his agony. I felt that such conduct could not be allowed. It pained me to see my little friend treated worse than 'the Private Secretary', and that by a lady whom he would fain have made his wife. I therefore removed the offending party, and kept her in solitary confinement in a separate tank, introducing in her stead one quieter and less quarrelsome. This was at about ten o'clock in the morning. But I shortly found that there was a new element of difficulty in getting my finned family to dwell together in peace and harmony. After some slight angry skirmishing, the two little males began a regular downright battle, using freely the strong spines which form the outer rays of the ventral fins. Never were seen more infuriated little monsters. It was, however, soon evident which was master, for ere long the victor was chasing the vanquished round and round the tank, seizing him at times by the pectoral fin, holding on and shaking him like a young bull-dog, the three females timidly looking on the while. At about three o'clock the victor's angry passions began to subside to some extent. He still had a suspicious mien; but with well-feigned nonchalance he began to carry about somewhat aimlessly any little bits of stick or broken pieces of alga he could find, as though he thus intended to proclaim that, now he was master of that tank, he was going to settle down there and build his nest. He was, however, evidently too perturbed

in his mind to do any serious work, for he continually left off to go and give the other fellow an additional bit of a drubbing; so that at five o'clock I took pity on the dejected little fish, and removed him to another tank. (A description of the way in which the victorious male built a nest here follows. See vol. iii, p. 428.) He was by this time in glorious colour, bright red all over the gills and along the ventral region, light creamy pink or blue on the back, his eye a very sapphire for brightness and purity of blue. Yet would not his mates be coaxed to the nest. Dress as he might, and air his finery as he would, they remained obdurate, insensate, and unmoved. Then would he show his not unnatural pique and annoyance by running at them from a distance and giving them most ungallant digs in the ribs. This is, however, it should be stated in extenuation of his conduct, a recognized part of the mysteries of stickleback courtship. I therefore removed the females, placing them in a tank close by, so that the little gentleman could show off his attire in one tank, while the ladies gazed at him admiringly from the other, without danger of being pestered by his too urgent attentions. After a time one of the females put on her wedding finery, her sides becoming marked with bands of deeper brown; and as she seemed anxious to join the merry little monarch of the other tank, I transferred her thither. He at once became much excited, and looked, if possible, rosier and bluer-eyed than ever. He soon dashed off to the nest to see that all was there in readiness, and passed through it, remaining inside half a minute or so. After having thus prepared his nest for her reception he returned to the female, and swam slowly round and round her, frequently passing in front of her. The gay rogue! He knew that she could not resist those rosy cheeks and that bright blue eye. Nevertheless he found it his duty to dig her several times in the ribs, and was clearly somewhat annoyed that she delayed so long to come to his nest. Unfortunately I was then called away from my room, so that I did not on this occasion see her pass through the nest and lay her eggs there." For further particulars regarding the home-life of this and other kinds of stickleback, the reader is referred to the delightful book from which the above extract is taken.

The Law of Beauty.—We have just seen that a male fish

may assume courtship colours of brilliant kind, but in some species the attractions are of a more elaborate nature. A good instance among British marine fishes is afforded by the Gemmeous Dragonet or Golden Skulpin (*Callionymus lyra*, fig. 1115), where the female is of a dull brown, and was formerly, under the name of the Sordid Dragonet, considered to be a distinct species. The male, however, is yellow, with spots and stripes of blue, besides which his first dorsal fin is relatively large, and

Fig. 1115.—Gemmeous Dragonet (*Callionymus lyra*). Male above; female below

its first ray is drawn out into a long slender filament, which appears to be of the nature of an ornament. Holt has described the courtship of an allied species, the Spangled Dragonet (*C. lineatus*), and says regarding the male that—"its head and body are indescribable mingled harmony of many shades of brown and blue and green, set off with light-blue spots and pearl-coloured stripes; the anterior dorsal fin, which can be erected like a high sail, is golden yellow, studded with many white-edged blue ocelli; the tail fin is a blend of brown and yellow, set with turquoise spots; the belly fin is like dark-blue velvet sown with rows of turquoise; the pelvic fins are like golden-green satin,

fringed with dark blue, and spangled with small turquoise spots; and the pectoral fins are of a delicate lavender-gray, with serried dark-brown spots. The female is but a dish-clout in respect of him." In still another species of Dragonet (*C. carebares*), however, it is the female which is beautiful, and she no doubt takes the lead in courtship. It is interesting to note that Alcock has described an Indian flat-fish (*Arnoglossus macrolophus*) in which the male possesses a long crest, owing to the excessive development of the rays at the front end of the dorsal fin, somewhat as in the Dragonets above described.

COURTSHIP AND MATING OF INSECTS (Insecta)

The Law of Battle.—The jaws of some male beetles are of enormous size (fig. 1116), and to these are sometimes added conspicuous horn-like outgrowths from the head or thorax. These features have suggested such names as "stag beetle",

Fig. 1116.—A Tropical Beetle (*Chiasognathus Grantii*). Male on left; female on right

"rhinoceros beetle", &c. Such structures may possibly be used in fights for the possession of mates, but this has not so far been proved, and the matter must remain unsettled until our knowledge of habits is more complete.

Various male insects have, however, been observed fighting for partners, and Darwin (in *The Descent of Man*) gives appa-

rently well-authenticated instances of this among digging wasp-like forms (*Cerceris*), Saw-Flies, Bees, and even Butterflies.

THE LAW OF BEAUTY.—Male insects, especially Butterflies, are often more beautiful and more conspicuous than individuals of the other sex, but it is necessary here to be cautious in drawing conclusions, for courtship is not the only business of life. That the female should often be in plain attire would often appear to be a protective measure, as it is more important for the welfare of the species that she should escape from enemies than her comparatively useless partner. The same explanation may be given where female butterflies are conspicuous as the result of protective mimicry (see vol. ii, p. 311). This line of argument, however, may easily be carried too far, and the usually brighter colours of the male in insects (and other animals) cannot be satisfactorily explained simply as one of the results of greater energy and activity. In many groups the eyes are complex and highly developed, and that they often minister to a "colour-sense" is generally admitted, the relations between insects and flowers, for example, affording much evidence in this direction (see p. 85). Admitting this, Wallace suggests that his theory of recognition marks (see pp. 132, 140) may account for many of the distinctive colours and markings of insects. In arguing against this view Poulton says (in *The Colours of Animals*)—"that the beauty of the colours and patterns displayed in courtship can never be explained by this principle. For the purposes of recognition, beauty is entirely superfluous and indeed undesirable; strongly-marked and conspicuous differences are alone necessary. But these, which are so well marked in Warning Colours, are not by any means characteristic of those displayed in courtship. If an artist, entirely ignorant of natural history, were asked to arrange all the brightly-coloured butterflies and moths in England in two divisions, the one containing all the beautiful patterns and combinations of colour, the other including the staring, strongly-contrasted colours, and crude patterns, we should find that the latter would contain, with hardly an exception, the species in which independent evidence has shown, or is likely to show, the existence of some unpleasant quality. The former division would contain the colours displayed in courtship and when the insect is on the alert, concealed at other times. The immense difference between the two divisions, the one most pleasing, the other highly repug-

nant to our æsthetic susceptibilities, seems to me to be entirely unexplained if we assume that the colours of both are intended for the purposes of recognition. But these great differences are to be expected if we accept Mr. Darwin's views; for the colours and patterns of the latter division appeal to a vertebrate enemy's sense of what is *conspicuous*, while those of the former appeal to an insect's sense of what is *beautiful*. It is, of course, highly remarkable that our own æsthetic sense should so closely correspond with that of an insect. I believe, however, that it is possible to account for this wonderful unanimity in taste. Our

Fig. 1117.—Orange-Tips (*Anthocharis cardamines*) in Centre (male left; female right). Cabbage-Whites (*Pieris brassicæ*) at Sides (male right; female left)

standards of beauty are largely derived from the contemplation of the numerous examples around us, which, strange as it may seem, have been created by the æsthetic preferences of the insect world."

Among our native species the Orange-Tip Butterfly (*Anthocharis cardamines*, fig. 1117) may probably be taken as a good example of courtship coloration. As in most other butterflies, these insects bring their wings together when they settle, and are then inconspicuous, as the under surfaces of these organs are protectively coloured, being white with greenish mottlings. This is more particularly true for the female Orange-Tip, which is often found sleeping among the blossoms of Wild Chervil (*Anthriscus sylvestris*), with the colour-scheme of which it harmonizes wonder-

fully. In both sexes the upper sides of the wings are whitish, while the front ones are tipped with black and have a spot in the centre. This can hardly be regarded as a protective arrangement, for it renders the insects conspicuous, though it is not a case of warning coloration; and in the male the effect is greatly heightened by the beautiful orange tips of the fore-wings, and since these present this peculiarity on their under as well as on their upper sides, the members of this sex are not so inconspicuous when they settle as are their partners. We can only conclude that the magnificent orange patches are courtship adornments.

It is very interesting to find that there are certain Moths in which the females are degenerate, their eyes, among other parts, having undergone retrogressive changes. Attractive colours and patterns in the male would be here superfluous, and, as a matter of fact, the males of such species are commonly dull and plain in appearance.

In some insects the usual rule is reversed, and the female is more beautiful than the male, as in the Cabbage Butterfly (*Pieris brassicæ*, fig. 1117) and other Whites, where there are black markings on the fore-wings of the former sex. Careful observations have demonstrated that in these species the females are the active wooers, while the males are coy (compare vol. iii, p. 465).

A considerable number of male insects proclaim their feelings in an audible manner, as in Grasshoppers and Crickets (see p. 38). Many beetles too, and some other sorts of insects, such as the Cicadas, are possessed of variously situated and constructed sound-producing organs, of which one or the chief use appears to be the production of love-calls (see vol. i, p. 352 and vol. iii, p. 224). Some male insects are also known which emit a strong musky odour.

That some female insects show a preference for one particular admirer seems to be pretty clearly demonstrated in the case of certain Moths, where a large number of males "assemble" round a female that has just come out of the chrysalis (fig. 1118). The following first-hand evidence on this point is given by Poulton (in *The Colours of Animals*):—"In many species of moths the males 'assemble' round the freshly-emerged female, but no special advantage appears to attend an early arrival. The female sits apparently motionless while the little crowd of suitors buzz around her for several minutes. Suddenly, and, as far as one can see,

without any sign from the female, one of the males pairs with her and all the others immediately disappear. In these cases the males do not fight or struggle in any way, and as one watches the ceremony the wonder arises as to how the moment is determined, and why the pairing did not take place before. All the males are evidently most eager to pair, and yet when pairing takes place no opposition is offered by the other males to the successful suitor. Proximity does not decide the point, for long beforehand

Fig. 1118.—"Assembling" of Oak Eggar Moths (*Lasiocampa quercus*). The female is the large pale moth, with simple antennæ, at the top of the cut.

the males often alight close to the female, and brush against her with fluttering wings. In watching this wonderful and complicated courtship one is driven to the conclusion that the female must signify her intention in some way unknown to us, and that it is a point of honour with the males to abide by her decision. I have watched the process exactly as I have described it in a common northern Noctua, the Antler Moth (*Charæas graminis*), and I have seen the same thing among beetles. The fact is well known to entomologists, and, as far as the evidence goes, it supports Darwin's theory."

THE FINDING OF MATES.—As implied in the preceding para-

graphs, an insect may be guided to a suitable mate in several ways. One of the most remarkable is found in the possession of an exceedingly delicate sense of smell by male insects, especially in cases where sight would often be useless. The moths which "assemble" are no doubt a case in point. When an adult female makes her appearance in the world she is quickly attended by a large number of admirers, although immediately before none were to be seen in the immediate vicinity. This fact is well known to collectors, who by the simple device of putting a female that has just left the chrysalis into a little box, with gauze sides,

Fig. 1119.—The Emperor Moth (*Saturnia carpini*). Male left; female right

and carrying the same into a suitable locality, are often able to capture large numbers of the corresponding male. In such cases the antennæ of the latter are large and complicated (fig. 1119), no doubt ministering to an unusually acute sense of smell. The mouth-parts of an insect of the kind are often much reduced, his last meal having been taken when he was still a voracious larva. Courtship and mating fill up the brief span of his adult life, and unless a partner be quickly found he is doomed to speedy death in a celibate condition. Hence the extraordinary development of the olfactory organs, to aid him in his quest.

In other cases the visual organs are unusually large, apparently with the same purpose. An instance of the kind is thus described by Carpenter (in *Insects, their Structure and Life*):—"Some male Mayflies are provided with peculiar large frontal eyes, carried on columnar outgrowths of the head, in addition

to normal lateral eyes like those of the females. The reduction of pigment and the presence of a thick layer of homogeneous fluid . . . has led to the conclusion that the special function of these eyes is to discern moving objects in the dusk, to enable the male to secure a mate in the airy twilight dance of the short-lived Mayflies" (fig. 1120).

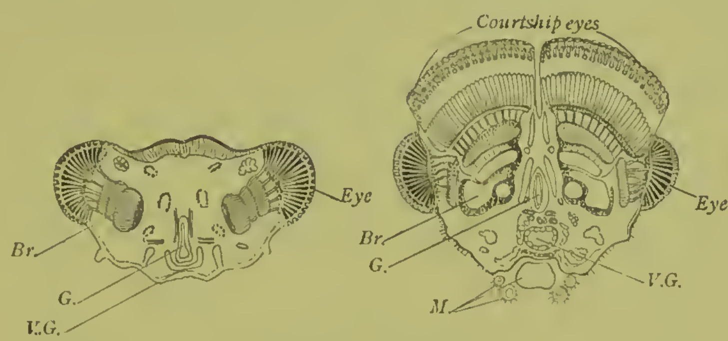


Fig. 1120.—Horizontal Sections through the Heads of a Male (right) and Female (left) Mayfly (*Cloë fuscata*), enlarged. *Br.*, Brain; *V.G.*, ventral ganglion; *G.*, Gullet; *M.*, mouth-parts.

In many of the nocturnal Beetles which are known as Glow-Worms the female is wingless and grub-like, as in our familiar native species (*Lampyris noctiluca*), and practically monopolizes the power of emitting a clear light from peculiar patches of skin along the sides of the body. As the eyes of the male in such cases are well developed, sometimes remarkably so, the object of the arrangement is tolerably clear. In some of the insects of this sort, native to South America, the difference in appearance between the male and female is particularly marked, the latter sex closely resembling the larva (fig. 1121). In Paraguay some of these grub-like females are known as "railway-beetles", being said to exhibit a "danger signal" at either end, and a row of "caution signals" along each side, or, to speak less metaphorically, possessing luminous organs in the positions indicated which respectively emit red and green light. A cynical remark might here be made, as to the appropriateness of such colours in the female sex.

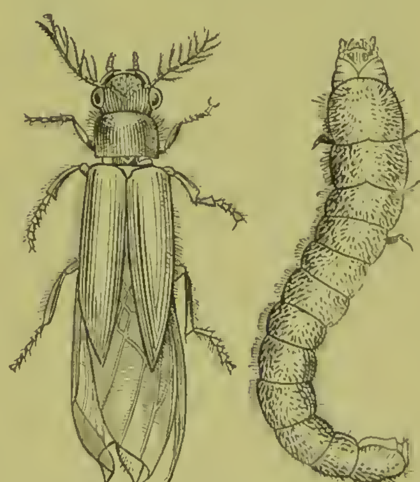


Fig. 1121.—A South American Glow-Worm (*Phengodes Hieronymi*), × 3. Male on left; female on right

There is still, however, much to be learnt as to the meaning of luminous organs in insects, for it appears that in species belonging to the same family as the Glow-Worms, *e.g.* the well-known Fire-Flies (*Luciola*) of South Europe, the light-giving power is more

strongly developed in the males. Nor can it well be deemed as probable that they are here the sought and not the seekers, for we should then expect to find the eyes of the female better developed than those of the opposite sex, but this is not the case.

COURTSHIP AND MATING OF SPIDERS (ARANEIDÆ)

The lot of a male spider is not altogether desirable, for he is much smaller than his prospective partner, who sometimes makes a meal of him. It is scarcely worth while in this case to make separate headings of the Laws of Battle and Beauty, for both may find their application at the same time. Dr. and Mrs. Peckham have investigated this subject as regards species of the family of Hunting Spiders (*Attidæ*). Their observations, some of which are quoted below (from *Papers of the Natural History Society of Wisconsin*, 1889), are intensely interesting, and clearly prove that the females of various species do not mate at random with any swain that offers, often being exceedingly fastidious, and sometimes tragically cruel. The males generally possess special markings and ornaments, which they display in ways that often appear grotesque; they also perform complex evolutions, some of these being rather weird "dances" (fig. 1122), of which one (for *Saitis pulex*) is thus described:—"He saw her as she stood perfectly still, 12 inches away; the glance seemed to excite him, and he moved toward her; when some 4 inches from her he stood still, and then began the most remarkable performances that an amorous male could offer to an admiring female. She eyed him eagerly, changing her position from time to time so that he might be always in view. He, raising his whole body on one side by straightening out the legs, and lowering it on the other by folding the first two pair of legs up and under, leans so far over as to be in danger of losing his balance, which he only maintained by sidling rapidly towards the lowered side. The palpus, too, on this side was turned back to correspond to the direction of the legs nearest it (see fig. 1122). He moved in a semicircle for about 2 inches, and then instantly reversed the position of the legs and circled in the opposite direction, gradually approaching nearer and nearer to the female. Now she dashes towards him, while he, raising his first pair of legs, extends them upward and forward to hold her off, but withal slowly retreats.

Again and again he circles from side to side, she gazing towards him in a softer mood, evidently admiring the grace of his antics. This is repeated until we have counted 111 circles made by the ardent little male. Now he approaches nearer and nearer, and when almost within reach, whirls madly around and around her, she joining and whirling with him in a giddy maze." One feels quite glad to hear that the suit of this particular male was successful. He was decidedly in luck, for we learn that the females

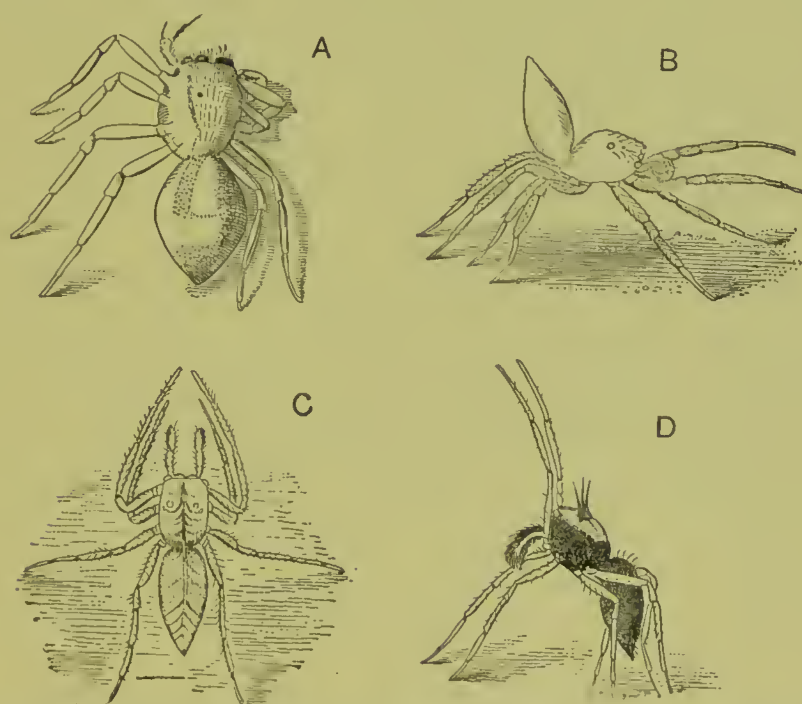


Fig 1122.—Courtship Attitudes of Male Spiders, enlarged. A, *Saitis pulex*, dancing. B, *Habrocestum splendens* approaching female. C and D, Red and black varieties of *Astia vittata* in approaching attitudes.

of his species are very fastidious, and frequently turn admirers away.

A number of males often compete for the good graces of a single female in some of the species observed, in which case the latter takes some time to make up her mind. Competing wooers from time to time interrupt their antics to tussle with one another. Boldness or persistence sometimes wins the day. The male of one species (*Dendryphantes capitatus*) may frisk around for hours displaying his special beauties, until "at last the female, either won by his beauty or worn out by his persistence, accepts his addresses". And in another form (*Hasarius Hoyi*) a male was brave enough to walk up to an evidently displeased female, "when she seized him and seemed to hold him by the head for

a minute, he struggling. At last he freed himself and ran away." Only to come back again, however, for we read that: "This same male after a time courted her successfully". Tragic courtships were also observed, as in the case of a particularly ruthless female (of *Phidippus morsitans*) who behaved thus:—"The two males that we provided for her had offered her only the merest civilities, when she leaped upon them and killed them".

In one remarkable species (*Astia vittata*) the female is red, and there are two kinds of male, red and black respectively, which court in different ways (fig. 1122). When they are rivals, black is invariably the winning colour.

It has been suggested that the small size and great activity of male spiders are adaptations which to some extent reduce the appalling dangers of courtship. In leaving this group the writer ventures to express a hope that many field naturalists may feel moved to observe the habits of common native forms on the lines so successfully followed by Dr. and Mrs. Peckham, in this and other fields (see p. 55). Anything approaching the skill and devotion of these investigators, applied to the study of almost any species, would most assuredly yield a rich harvest of valuable results.

COURTSHIP AND MATING OF CRUSTACEANS (CRUSTACEA)

Comparatively little is known about the love affairs of the higher members of this group, which deserves far more attention in this matter than has so far been bestowed upon it. It will perhaps suffice here to quote an exceedingly interesting account which is given by Alcock (in *A Naturalist in Indian Seas*) of a little Fiddler Crab (*Gelasimus annulipes*, fig. 1123), which is very abundant on the mud-flats at the mouths of the Godávari and Kistna. The pincers of the female are small, and only used in feeding, but in the male one of them is of great size and bright pink in colour, serving as an ornament and also as a weapon. Alcock thus describes the courtship of these little

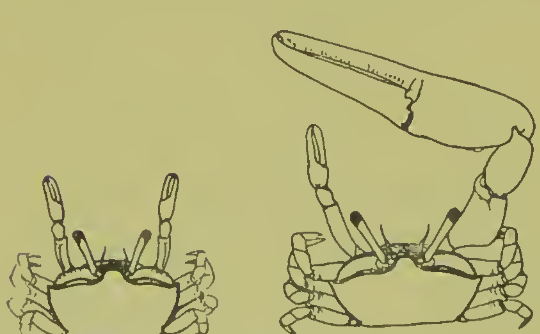


Fig. 1123.—Indian Fiddler Crab (*Gelasimus annulipes*). Female on left; male on right

animals:—" Landing one afternoon in March upon a cheerful mud-flat of the Godávari sea-face, I was bewildered by the sight of a multitude of small pink objects twinkling in the sun, and always, like will-of-the-wisps, disappearing as I came near to them, but flashing brightly on ahead as far as the eye could reach. It was not until I stayed perfectly quiet that I discovered that these twinkling gems were the brandished nippers of a host of males of *Gelasimus annulipes*. By long watching I found out that the little creatures were waving their nippers with a purpose—the purpose apparently being to attract the attention of an occasional infrequent female, who, uncertain, coy, and hard to please, might be seen unconsciously sifting the sand at the mouth of her burrow. If this demure little flirt happened to creep near the burrow of one of the males, then that favoured individual became frantic with excitement, dancing round his domain on tiptoe and waving his great cherry hand as if demented. Then, if another male, burning with jealousy, showed a desire to interfere, the two puny little suitors would make savage back-handed swipes at one another, wielding their cumbrous hands as if they had no weight at all.

Some of the Crustaceans possess the power of emitting sounds (see p. 37), possibly to serve as love-calls, and the courtship habits of such species would probably prove interesting.

CHAPTER LXV

ASSOCIATION OF ANIMALS—MESSMATES OR COMMENSALS (COMMENSALISM)

Messmates are organisms of different species which are more or less closely associated, to the benefit of at least one partner in the concern. Cases of this sort are grouped under the head of Commensalism. Mutualism (*Symbiosis*) is a much more intimate kind of relation between two organisms, to the advantage of both, as already described. The best examples of such Mutualism or Symbiosis involve a partnership for certain cases where plants and animals are thus associated (see p. 75). It is doubtful whether any two kinds of animal live together in this intimate fashion. Parasites are animals which live on or in other animals, at their expense, and to their detriment. Parasitism also includes cases where one organism concerned is a plant (see p. 76).

In a broad sense all the animals which live and feed together in the same place may be regarded as messmates, and the relations between such species may be very complex. It will, however, be well to restrict the term to cases where the connection is of closer and more constant nature, involving the interests of definite species. But it must not be forgotten that this kind of association has no doubt gradually arisen from relations which were originally of more casual kind. So many instances of Commensalism are known that it will only be possible to describe a few of the more striking examples.

FISHES (PISCES) AS MESSMATES

Some extraordinary cases have been described where small bony fishes take up their quarters within the digestive organs of lower animals, sallying forth from these peculiar refuges as circumstances dictate. The most familiar instance of this is

afforded by a slender form (*Fierasfer*) living in the gullet of a kind of Sea-Cucumber, which does not appear to gain anything by way of return for its hospitality. Some of the giant sea-anemones living on the Great Barrier Reef of Australia harbour gaily-coloured little fishes belonging to the Perch family, a given species of anemone being the home of a particular species of fish. The fish-guest (*Amphiprion percula*) of one such obliging zoophyte (*Discosoma Kenti*) is orange-red in colour, marked by three cross-bands of pearly white, these and the fins being edged with black. An allied anemone (*D. Haddoni*) entertains a little fish (*A. bicinctus*) which differs from its relative in possessing two bands only, while the black edging is absent.

Fig. 1124.—Indian Rock Perch (*Minous inermis*) with Commensal Polypes (*Stylactis minoi*)

The same anemone also extends its hospitality to a red-and-white Prawn (*Palæmon*). In these cases the fishes not only find a secure shelter, the stinging properties of which ward off attack, but also probably filch some of the food of their living homes. On the other hand, it is possible, as suggested by Saville Kent, who has described the associated animals, that the bright tints of the guests serve as "lure colours", enticing animals which serve as food for the anemones.

The relations just described are occasionally reversed, as when a fish serves as a moving home to zoophytes. Alcock describes a Rock Perch (*Minous inermis*, fig. 1124), native to the Indian Ocean, as being always more or less encrusted with small polypes (*Stylactis minoi*), which, being of course carried about from place to place, have a better chance of getting abundant food than if they were attached to a stone or sea-weed. The fish may perhaps derive some protection from the stinging properties of its guests.

MOLLUSCS (Mollusca) AS MESSMATES

A marine snail (*Pleurotoma symbiotes*, fig. 1125), living in the deep water of the Indian Ocean, always has its shell more or less encrusted with colonial sea-anemones (*Epizoanthus*). Both animals are no doubt benefited, for the mollusc is protected, while the anemones are carried about.

A number of small Bivalve Molluscs are associated with burrowing Sea-Urchins or Crustaceans. One such bivalve (*Montacuta ferruginosa*), native to South Devon, lives in the dwelling which a Heart-Urchin (*Echinocardium cordatum*) excavates in muddy sand. The circulation of sea-water which takes place within the burrow (see vol. iii, p. 357) ensures a constant supply of food by which the mollusc benefits. In places where the sand is loose and wet the Heart-Urchin is in the habit of coming to the surface, along which it makes its way, but the lodger is not thereby left behind, for it spins byssus threads that attach it to its partner.

Fig. 1125.—An Indian Sea-Snail (*Pleurotoma symbiotes*) with Commensal Sea-Anemones (*Epizoanthus*)

A rare little British Bivalve (*Lepton squamosum*) inhabits the burrow of a prawn-like Crustacean (*Upogebia stellata*), and, having an exceedingly flat shell, does not interfere with the movements of its protector. A similar partnership exists on the coast of Florida between two species related to the preceding, while on the shores of Oregon and California a third association of the sort is more intimate, for here the Lepton attaches itself to the abdomen of the Upogebia. A burrowing Australian prawn (*Axius plectorhynchus*) harbours two species of a kind of bivalve (*Ephippodonta*), which is never found elsewhere. The flatness, so necessary to allow of the restless movements of the prawn, is here produced by the valves of the mollusc opening to their fullest extent. This particular prawn appears to be a specialist in the matter of providing lodgings, for four other bivalves (one species of *Kellia* and three of *Mylitta*) find a commodious home in its burrow, which also contains an orange-coloured sponge. The last possibly serves as a protection to the crustacean, but the arrangement would appear to be quite one-sided so far as the molluscs are concerned.

As with Fishes (see p. 171), Bivalve Molluscs are not always lodgers in the case of partnerships, but may afford shelter to weaker creatures. A well-known instance is that of the little rounded Lodger-Crabs (*Pinnotheridæ*), in which the eyes have undergone great reduction. Among bivalves which provide them with homes may be mentioned Horse-Mussels (*Modiola*), Oysters (*Ostrea*), Pinnas, and Tridacnas, while some crabs of the kind take up their quarters within ascidians or sea-cucumbers. Van Beneden thus speaks of these little lodgers (in *Animal Parasites and Messmates*):—"It is not a taste for voyaging which tempts them, but the desire of having always a secure retreat in every place. The pinnothere is a brigand who causes himself to be followed by the cavern which he inhabits, and which opens only at a well-known watchword. The association redounds to the advantage of both; the remains of food which the pinnothere abandons are seized upon by the mollusc [or, rather, some of its remains may be carried by ciliary action into the mouth of the mollusc]. It is the rich man who instals himself in the dwelling of the poor, and causes him to participate in all the advantages of the position. The pinnotheres are, in our opinion, true messmates. They take their food in the same waters as their fellow-lodger, and the crumbs of the rapacious crabs are doubtless not lost in the mouth of the peaceful mussel. There is no doubt that these little plunderers are good lodgers, and if the mussels furnish them with an excellent hiding-place and a safe lodging, they themselves profit largely by the leavings of the feast which fall from their pincers. Little as they are, these crabs are well furnished with tackle, and advantageously placed to carry on their fishery in every season. Concealed in the bottom of their living dwelling-place (a den which the mussel transports at will) they choose admirably the moment to rush out to the attack, and always fall on their enemy unawares. Some of these pinnotheres live in all seas, and inhabit a great number of bivalve molluscs." The habits of these curious little crabs attracted attention in remote times, and have been the subject of much curious speculation. Stebbing (in *A History of Crustacea*) makes the following remarks upon the ancient views, and discusses the origin of the commensal habit:—"The name *Pinnoteres* means one that watches or guards the *Pinna*, and there can be little doubt that it was the form used by Aristotle

[and not *Pinnotheres*, meaning one that 'hunts the *Pinna*'], seeing that he also speaks of *Pinnophylax*, a word of precisely the same meaning. Not only Aristotle, but many succeeding writers of renown, such as Cicero, Pliny, and seemingly Linnæus himself, accepted the opinion that there was a compact between the mollusc and the crustacean for their mutual benefit. Whenever little fishes swam in between the expanded valves of the mollusc, it was supposed that its companion gave it a little friendly nip, upon which the valves snapped together, the prey was secured, and shared between the confederates. A similar policy was pursued to exclude the intrusion of a dangerous foe. The great antiquity of the belief is attested by the fact that the Egyptians in their hieroglyphics made use of the pinna and crab to symbolize the helplessness of a man without friends. That the belief was untenable was pointed out by many naturalists, from Gesner down to Cuvier, on the ground that molluscs do not feed on little fishes, and that the residence of the crabs within the valves was sufficiently explained by the prevailing softness of the carapace in this family. This indeed applies chiefly to the females, and it is the females that appear to be most frequently found thus domiciled. It is so much the nature of crustaceans to take refuge in any sort of cleft or cranny that the first entrance of the *Pinnotheres* into any sort of bivalve can be easily understood. When the residence proved to be peculiarly secure, the shell of the crab would by degrees lose a hardness that was no longer especially necessary. That the crab may at times be useful to the mollusc seems after all not so very improbable, for at the approach of an enemy so nervous a creature as a crab would no doubt begin to scuttle about, and in this way communicate its terror to its more apathetic companion, which would then naturally close its doors against the danger."

JOINTED-LIMBED ANIMALS (ARTHROPODA) AS MESSMATES

We are here especially concerned with Insects and Crabs, regarding which groups there is a great wealth of material from which to select, so that only a few examples can be here given, supplementing, for the latter animals, what has just been said about Pinnotheres.

INSECTS (INSECTA) AS MESSMATES.—It will be convenient to limit our attention to Bees and Ants, remembering that both belong to an order (Hymenoptera—Membrane-winged Insects) of which the members are distinguished by an extraordinary amount of specialization, associated with mental qualities of no mean order.

Bees as Messmates.—Many species are known of what may be called, for want of a better word, Lodger Bees (*Psithyrus*), each kind of which lives in the nest of some sort of Humble-Bee (*Bombus*). In nearly all such cases the guest closely resembles its entertainer in appearance, and the two dwell together in a perfectly friendly way. The arrangement is of a one-sided nature, for the lodger not only has free quarters, but also makes free use of the provisions stored up by the industrious humble-bee, which, however, is not directly harmed by the association. But as a result of the raids made upon the larder by its lazy lodger, it is not able to rear nearly so many young ones as would otherwise be the case. A nest of a species of Humble-Bee (*Bombus variabilis*), examined by Hoffer in early autumn, contained only a queen and fifteen workers, together with eighteen Lodger-Bees (*Psithyrus campestris*), of which eight were females. But for the strain on the commissariat there would, it was estimated, have been 200 humble-bees in the colony, or even more.

Ants as Messmates.—Occasion has already been taken to note the curious relations which exist between Ants and Aphides, the latter being fed and tended in return for their services as "cows" (see p. 119). Even more extraordinary are the habits of certain Slave-making Ants, which press other ants into their service, employing them in all the varied duties of the nest. The slavers conduct organized raids from time to time, in order to keep up the number of their dependants, and it must be said that these take very kindly to their enforced labours. A notable European example is afforded by the large Amazon Ant (*Polyergus rufescens*), which enslaves the small Brown Garden Ant (*Formica fusca*). The following graphic account of the matter is given by Newman (in *An Introduction to the History of Insects*), and some of the details are set forth in fig. 1126:—"The most remarkable fact connected with the history of ants is the propensity possessed by certain species to kidnap the workers of other species, and compel them to labour for the benefit of the

community, thus using them completely as slaves; and, as far as we yet know, the kidnappers are red or pale-coloured ants, and the slaves, like the ill-treated natives of Africa, are of a jet black [or at any rate dark in hue]. The time for capturing slaves extends over a period of about ten weeks, and never commences till the male and female ants are about emerging from the pupa stage, and thus the ruthless marauders never interfere with the continuation of the species; this instinct seems specially provided, for were the slave ants created for no other end than to fill the

Fig. 1126.—Slave Raid of Amazon Ants (*Polyergus rufescens*)

station of slavery to which they appear to be doomed, still even that office must fail were the attacks to be made on their nests before the winged myriads have departed, or are departing, charged with the duty of continuing their kind. When the red ants are about to sally forth on a marauding expedition, they send scouts to ascertain the exact position in which a colony of negroes may be found; these scouts having discovered the object of their search, return to the nest and report their success. Shortly afterwards the army of red ants marches forth, headed by a vanguard, which is perpetually changing; the individuals which constitute it, when they have advanced a little before the main body, halting, falling into the rear, and being replaced by others; this vanguard consists of eight or ten ants only. When they have arrived near the negro colony, they disperse, wandering through the herbage

and hunting about, as if aware of the propinquity of the object of their search, yet ignorant of its exact position. At last they discover the settlement, and the foremost of the invaders, rushing impetuously to the attack, are met, grappled with, and frequently killed by the negroes on guard; the alarm is quickly communicated to the interior of the nest; the negroes sally forth by thousands, and, the red ants rushing to the rescue, a desperate conflict ensues, which, however, always terminates in the defeat of the negroes, who retire to the innermost recesses of their habitation. Now follows the scene of pillage; the red ants with their powerful mandibles tear open the sides of the negro ant-hill, and rush into the heart of the citadel. In a few minutes each of the invaders emerges, carrying in its mouth the pupa of a worker negro, which it has obtained in spite of the vigilance and valour of its natural guardians. The red ants return in perfect order to their nest, bearing with them their living burdens. On reaching the nest the pupæ appear to be treated precisely as their own, and the workers, when they emerge, perform the various duties of the community with the greatest energy and apparent goodwill; they repair the nest, excavate passages, collect food, feed the larvæ, take the pupæ into the sunshine, and perform every office which the welfare of the colony seems to require; in fact, they conduct themselves entirely as if fulfilling their original destination." The Amazon Ants are practically incapable of feeding themselves, being thus almost entirely dependent upon the good offices of their slaves. They are, however, so fierce and warlike that their dominance in the mixed community is easily understood. Far more remarkable is the mode of life of a rare ant (*Anergates atratulus*), native to Central Europe, in which there is no worker caste, but only females and wingless males, both sexes being weak and helpless. Small numbers of them are found associated with numerous workers of a small species (*Tetramorium cæspitum*), by which they and their offspring are tended, and which are vastly their superiors in strength and energy. How the association comes about is unknown, but it has been suggested that a young fertile Anergates female makes her way into a Tetramorium nest, destroys the queen and young, and is accepted by the workers as their nominal sovereign. A more likely view is that such a female enters a Tetramorium nest containing only workers, and it appears that such nests do some-

times occur. More observations are necessary in order to settle the question. Lord Avebury makes the following conjectures (in *Ants, Bees, and Wasps*) as to the past history of Anergates: —"We may safely conclude that in distant times their ancestors lived, as so many ants do now, partly by hunting, partly on honey; that by degrees they became bold marauders, and gradually took to keeping slaves; that for a time they maintained their strength and agility, though losing by degrees their real independence, their arts, and even many of their instincts; that gradually even their bodily force dwindled away under the enervating influence to which they had subjected themselves, until they sank to their present degraded condition—weak in body and mind, few in numbers, and apparently nearly extinct, the miserable representatives of far superior ancestors, maintaining a precarious existence as contemptible parasites of their former slaves."

Ants not only keep cattle and slaves, but are also known, in many cases, to entertain quite a number of insect guests, which they feed and otherwise look after, their attentions being probably often rewarded by some sort of sweet substance produced by their visitors, though this does not appear to be invariably the case. Beetles are especially common among such true guests, and many species (as also of other sorts of insect) are to be found nowhere else, being then known as ants'-nest insects (myrmecophilous insects). They often somewhat resemble their entertainers in appearance, and are fully versed in the ways of the nest. The latter point is well illustrated by the way in which they stroke ants that have returned from foraging, to induce them to disgorge some of the honey with which the crop is distended (fig. 1127, A). One very remarkable case has been described in which certain ants (*Lasius*) carry about mites on their bodies, feeding them from time to time, and otherwise treating them with great consideration, though apparently without deriving any corresponding benefit.

Besides the true guests just mentioned, there may be also various sorts of tolerated guest, which the ants treat with more or less indifference. A case in point is afforded by a small ant (*Formicoxenus nitidulus*), which is permitted to live unmolested in the hills of the large Horse-Ant (*Formica rufa*). A somewhat amusing instance is that of a species of Tassel-tail (*Grassiella polypoda*), which maintains itself in the nest of a kind of ant

t

(*Lasius mixtus*). In fig. 1127, B is represented a little drama which appears to be frequently enacted by the two kinds of insect. One ant is seen in the act of feeding another by squeezing a drop of sweet fluid out of its crop. A tassel-tail is just about to steal this drop, being also prepared to beat a hasty retreat after accomplishing the impudent theft.

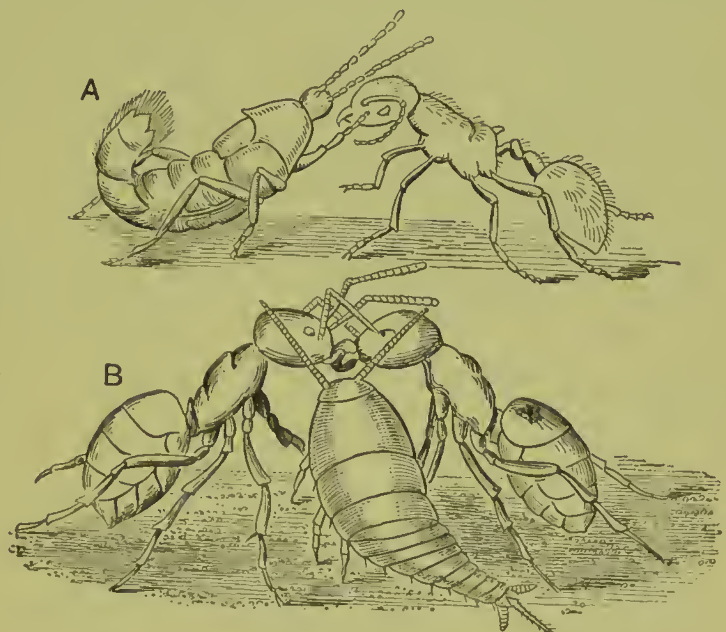


Fig. 1127.—Scenes in Ant Life, enlarged. A, an Ants'-nest Beetle (*Atemeles*) asking to be fed. B. A Tassel-Tail (*Grassiella polypoda*) about to steal a drop of food which one ant is giving to another.

CRABS (BRACHYURA) AS MESSMATES.—Partnerships between Crabs and Sea-Anemones are of common occurrence, the former being benefited by the stinging properties of the Zoophytes, which in their turn are placed under favourable conditions as regards feeding. Such an association between a Buffoon-Crab (*Dorippe facchino*) and an Anemone (*Cancrisocia expansa*) is shown in fig. 1128. An arrangement, differing in detail, has been described in the case of two kinds of crab native to Mauritius, each of which has two anemones as messmates, one fixed to each of the large pincers.


Fig. 1128.—Buffoon-Crab (*Dorippe facchino*) with Commensal Sea-Anemone (*Cancrisocia expansa*), reduced

Hermit-Crabs are particularly notable for the partnerships which they contract with Zoophytes, probably because the shells in which they shelter their soft tails afford a convenient surface for attachment. Two British species, for example, *Eupagurus Bernhardus* and *E. Prideauxii*, have as their respective associates two different species of Cloak-Anemone (*Adamsia Rondeletii* and *A. palliata*). Regarding the latter hermit-crab Stebbing (in *A History of Crustacea*) speaks as follows:—"Surmises are sometimes made as to the advantages

which the companions may hope to gain from the alliance. The anemone may obviously obtain a greatly increased range for supplies of food, by the superior locomotive powers of the hermit, and though the weight of both anemone and shell may seem an unnecessary encumbrance to the crustacean, that objection is gradually diminished by the circumstance that the anemone in course of time almost entirely absorbs the shell. On the other hand, the presence of the anemone may be a very valuable protection to the hermit, since numerous fishes are in the habit of swallowing these recluses, shell and all, merely spitting out the shell after they have digested its inmate. But it is most probable that to many fishes an *Adamsia palliata* would be by no means an agreeable morsel, even when flavoured with crab-sauce. It is also not unlikely that the anemone may contribute to the commissariat by throwing out its darts as some swift-gliding shrimp passes by, and thus reducing it to a condition in which it can be captured by the pagurid." In some of the hermit-crabs the shelly dwelling is coated by a hydroid zoophyte (*Hydractinia echinata*), which by its growth is able to enlarge the hermit's home, thus saving him the trouble of looking out for fresh quarters, as in other cases is done from time to time as the exigencies of growth may determine. It is said that when a hermit in partnership with an anemone changes his abode he carefully detaches his messmate from the old domicile and attaches it to the new one.

The messmate of an American hermit (*Eupagurus pubescens*) is a colonial sea-anemone (*Epizoanthus*), which gradually absorbs the protective shell, constituting thereafter an expansible covering, which obviates change of residence. Anderson's Blanket-Crab (*Chlænopagurus Andersoni*, fig. 1129), native to the Indian Ocean, is associated with a similar anemone, and is said never to use a cast-off shell as a refuge. Alcock (in *A Naturalist in Indian Seas*) thus summarizes in an interesting way the salient features of associations of the kind:—" Sea-anemones here [*i.e.* on the Orissa coast], for the most part, were found attached to the shells of hermit-crabs, &c., a case of Hobson's choice sometimes, no doubt, but also sometimes illustrating that happy bond of commensalism, or Platonic union, which is one of the most valuable object-lessons for man's edification that marine zoology affords. When two animals of different grades in the zoological scale live

together in such a fashion that each one assists the other in some definite way, while doing it no manner of harm, they are termed commensals or messmates. For instance, when a hermit-crab and a sea-anemone live together, the hermit-crab, being by nature a very ill-clad and vulnerable animal, acquires by the partnership a thick and easily-adjustable greatcoat, while the sea-anemone, being by nature a hopeless lump of an animal, dependent on chance currents for its food and oxygen, acquires an engine and intelligent engine-driver all in one, which are always carrying it in the way of the necessaries of life; and yet with this mutual assistance there goes absolute independence in all other respects, such as mistresses and servants, who would both be none the worse for a little knowledge of the principles of zoology, never dreamt of."

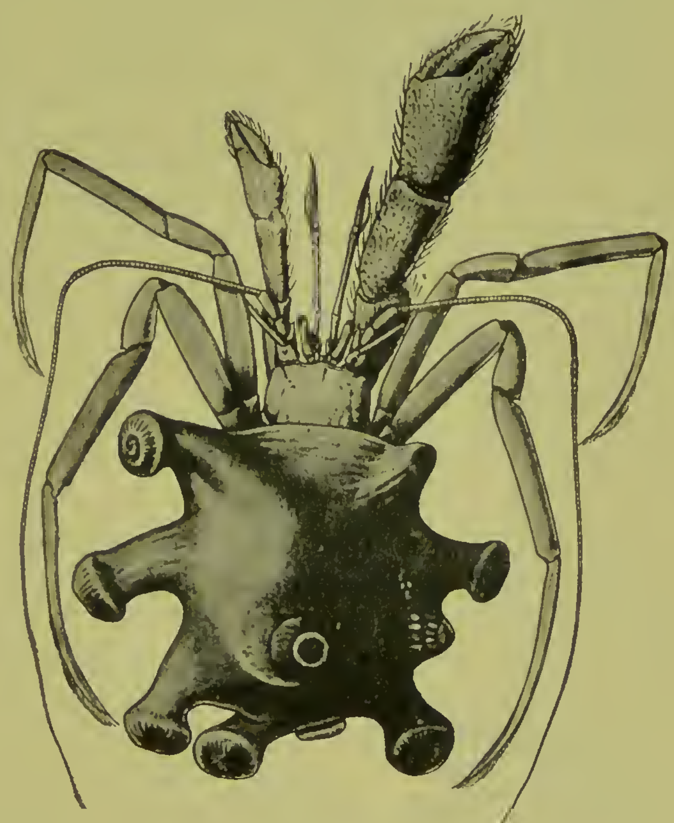


Fig 1129.—Anderson's Blanket-Crab (*Chlænopagurus Andersoni*) with Commensal Sea-Anemones (*Epizoanthus*)

Certain crabs have sponges as messmates, the mutual advantages being much the same as before, it being remembered that sponges are usually avoided by predaceous creatures which appreciate the flavour of crustaceans. In the members of one family of crabs (*Dromidæ*) the last pair of legs are modified in relation to the commensal habit, being small, with more or less hook-like tips, and having shifted somewhat towards the upper side of the body. They are used to hold a sponge or some other passive messmate that serves as a sort of living cape, promoting concealment and protection. In the common Sponge-Crab (*Dromia vulgaris*), as the popular name indicates, this companion is a sponge. So also in a little species (*Cryptodromia pileifera*, fig. 1130) from the coral-reefs

of the Andaman Islands, and in this case the messmate is cap-shaped, and fits very neatly to the back of its active partner.

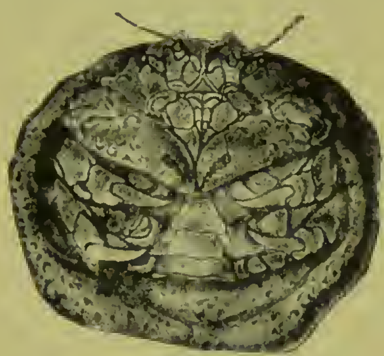


Fig. 1130.—Under View of an Andaman Sponge - Crab (*Cryptodromia pileifera*) with Commensal Sponge

Hermit-Crabs are also in some instances associated with sponges, one of them (*Eupagurus Cuanensis*) being particularly notable in this respect, for the shell in which it lives is completely overgrown by an orange-coloured species (*Suberites domunculus*), leaving only a small aperture to serve as a front door. As this particular sponge is not only full of sharp spicules, but also disagreeable to both smell and taste, we might expect it to prove a very efficient protection, and Garstang has found by actual experiment that fishes find it extremely repulsive.

SIPHON-WORMS (GEPHYREA) AS MESSMATES

Some of these curious worms take up their quarters in empty shells, and in certain cases this has led to a curious kind of commensalism, to some extent reminiscent of what happens in hermit-crabs. For just as anemones attach themselves to the dwellings of hermits, so do certain simple corals affix themselves to the shells appropriated by siphon-worms, afterwards increasing in size so as to conceal these from view, so that in the end we find the base of the coral traversed by a kind of tunnel serving as the home of the worm (fig. 1131). Three different species of coral (*Heteropsammia Michelini*, *Heterocyathus æquicostatus*, and *Stephanoseris Rousseaui*) have been described from the Indian Ocean, each living with a distinct species of a kind of siphon-worm (*Aspidosiphon*). Shipley has carefully examined the species (*A. corallicola*) associated with the first-named coral, and makes the following interesting remarks about the partnership (in *Ceylon Pearl Fishery Report*):—"The whole question of such com-

Fig. 1131.—Under (left) and Upper (right) Sides of a Cup-Coral (*Heteropsammia Michelini*), showing opening of the dwelling of its Commensal Siphon-Worm (*Aspidosiphon corallicola*)

mensalism as exists between the *Aspidosiphon* and the coral is an interesting one. Commensalism is usually looked upon as conferring some mutual advantage on the contracting parties, and one or the other of these usually seeks the other out. But in the case in question the mutual advantage is far to seek. It can hardly help the coral to have a large proportion of its base burrowed by a spacious canal, but the fact that the Gephyrean pulls the otherwise immovable coral about may be, and probably is, an advantage to the Cœlenterate. On the other hand, the Gephyrean gains protection and a home more spacious than the Gastropod shell affords. The *Aspidosiphon* can hardly find or attract the larval coral to come to rest on its borrowed shell, and it is unlikely that the larva is especially on the outlook for such shells as are inhabited by Gephyrea. It seems more probable that the *Aspidosiphon* may select for its home a Mollusc shell which already bears a young coral, but the whole matter seems to demand more careful study. It is certainly remarkable that three distinct genera of coral, each with but one species, should be inhabited by three distinct species of *Aspidosiphon*, and that neither commensal has hitherto been found apart from the other." In some cases, at least, there would appear to be a third partner in the concern, for numbers of a kind of minute bivalve mollusc were found closely attached to the outside of the siphon-worms. Regarding them Shipley remarks:—"These were so closely adpressed to the skin of the *Aspidosiphon* as to indent it, appearing as little pearls set in a matrix. The advantage they obtained by taking up such a position is not very evident, but there they were, and as far as one could judge they were, until Professor Herdman dropped them into his collecting-jar, flourishing."

CHAPTER LXVI

ASSOCIATION OF ANIMALS—PARASITES

Parasites live at the expense of larger animals, either using various parts of them as aliment, or robbing them of the food which they have digested. The less modified forms (ecto-parasites) attack their "hosts" from the outside, making either an occasional visit, as in the blood-sucking Leeches, or dwelling permanently upon the skin, a condition familiarly illustrated by many of the Fleas. Much greater modification is found among those parasitic animals (endoparasites) which live within their hosts, *e.g.* Flukes and Tape-Worms, and many of these pass through a complicated life-history, in the course of which two or more hosts may be utilized as homes. Many forms are parasites for a part of their lives only, being free-living when young or adult as the case may be, and not infrequently there is a difference between the sexes in this respect, one of them (especially the female) being a parasite and the other not.

The origin of parasitism is not far to seek. It may be regarded in many cases as an outcome of the carnivorous habit. Small animals attacked larger ones which they were unable to kill and devour in a straightforward fashion, so to speak, and the convenience of preying upon a highly nutritious living food-supply, at which it was possible to "cut and come again", naturally led to further evolution of the habit. And it is not difficult to imagine the stages by which external parasites gradually became internal parasites. Sometimes, too, no doubt, parasitism has resulted from the association of messmates (commensalism) in which the partnership was from the first one-sided, or ultimately became so. It would also seem that in many instances the habit possessed by many female animals of seeking out some secure refuge for egg-laying purposes has been the starting-point of parasitic relations. However originated, it is at least certain that the phenomenon of

parasitism is very widely spread, and there is probably no animal which does not unwillingly entertain unwelcome guests that make no return for services rendered. As De Morgan sings (in *The Budget of Paradoxes*):—

"Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas, and so *ad infinitum*;
And the great fleas themselves, in turn, have greater fleas to go on,
Whilst these again have greater still, and greater still, and so on".

The general progress of evolution has been from the less to the more specialized as a result of adaptation to increasingly complex surroundings, but to this parasites constitute a striking exception. Free quarters and free rations having been provided for them, they have taken but little part in the active struggle for existence, and well illustrate the principle of Degeneration. They are on the down-grade, adapting themselves to comparatively simple conditions. Hence we find that complex organs of digestion, circulation, respiration, and locomotion, together with nervous system and sense-organs, have undergone more or less reduction in thoroughgoing parasites, though, on the other hand, they have frequently developed special piercing, sucking, and adhesive structures, enabling them to exploit their living food-supply, and to maintain their position. The great danger attending this particular mode of life is constituted by the smallness of the chance of transfer from one host to another. In the more helpless forms this difficulty is often met by the practice of living in two or more different hosts which eat or prey upon one another; the adult egg-producing stage, being the most important, is commonly associated with the strongest and most highly organized of these, the so-called "final host". The biological relations between the successive living refuges is always such as to maintain most surely "the vicious circle of parasitism". Even more important is the immense fecundity of parasites, a necessary provision, for the chances of survival are extremely small. Leuckart calculated, for example, that any one egg of a tape-worm has only one chance in some 83,000,000 of giving rise to an adult.

What is called Brood Parasitism, where an animal shirks the duty of bringing up its own young, will be considered in this section, although it is by no means the same thing as true parasitism.

BIRDS (AVES) AS BROOD-PARASITES

The Common Cuckoo (*Cuculus canorus*), as everyone knows, deposits her just-laid egg in the nest of some small bird, carrying it there in her bill. The proceedings of the young cuckoo, as observed by Mrs. Blackburn, are thus described by Lloyd Morgan (in *Animal Behaviour*):—"One of the most remarkable instincts of young birds is that of the cuckoo, which ejects eggs and nestlings from the home of its foster-parent. Mrs. Hugh Blackburn found a nest which contained two meadow-pipits' eggs, besides that of a cuckoo. On a later visit the pipits were found to be hatched, but not the cuckoo. At the next visit, which was after an interval of forty-eight hours, 'we found the young cuckoo alone in the nest, and both the young pipits lying down the bank, about ten inches from the margin of the nest, but quite lively after being warmed in the hand. They were replaced in the nest beside the cuckoo, which struggled about until it got its back under one of them, when it climbed backwards directly up the open side of the nest, and hitched the pipit from its back on to the edge. It then stood quite upright on its legs, which were straddled wide apart, with the claws firmly fixed half-way down the inside of the nest, among the interlacing fibres of which the nest was woven, and, stretching its wings apart and backwards, it elbowed the pipit fairly over the margin, so far that its struggles took it down the bank instead of back into the nest [fig. 1132]. As it was getting late, and the cuckoo did not immediately set to work on the other nestling, I replaced the ejected one and went home. On returning next day, both nestlings were found dead and cold, out of the nest' (*Birds from Moidart and Elsewhere*)." Similar habits have been described for the Cow-Birds (species of *Molobrus*) of America. One species of these (*M. rufaxillaris*) actually lays its eggs in the nest of a related species (*M. badius*), which is industrious enough to build one for itself. It may further be remarked in passing that some kinds of Cuckoo also construct nests, and bring up their young in the usual way.

Newton, after speaking of the social nesting-habits of certain birds, makes the following suggestions as to the origin of brood-parasitism (in *A Dictionary of Birds*):—"In the strongest contrast to these amiable qualities is the parasitic nature of the Cuckows of the Old World and the Cow-Birds of the New, but

this peculiarity of theirs has already been dwelt upon. Enough to say here that the egg of the parasite is introduced into the nest of the dupe, and after the necessary incubation by the fond fool of a foster-mother the interloper successfully counterfeits the heirs, who perish miserably, victims of his superior strength. The whole process has been often watched, but the reflective naturalist will pause to ask how such a state of things came about, and there is not much to satisfy his enquiry. Certain it is that some birds, whether by mistake or stupidity, do not unfrequently lay their eggs in the nests of others. It is within the knowledge of many that Pheasants' eggs and Partridges' eggs are often laid in the same nest, and it is within the knowledge of the writer that Gulls' eggs have been found in the nests of Eider-Ducks, and *vice versâ*; that a Redstart and a Pied Fly-Catcher, or the latter and a Titmouse, will lay their eggs in the same convenient hole—the forest being rather deficient in such accommodation; that an Owl and a Golden-Eye will resort to the same nest-box, set up by a scheming woodsman for his own advantage; and that the Starling, which constantly dispossesses the Green Woodpecker, sometimes discovers that the rightful heir of the domicile has to be brought up by the intruding tenant. In all such cases it is not possible to say which species is so constituted as to obtain the mastery; but just as it is conceivable that in the course of ages that which was driven from its home might thrive through the fostering of its young by the invader, and thus the abandonment of domestic duties would become a direct gain to the evicted householder, so the bird which, through

Fig 1132.—Young Cuckoo (*Cuculus canorus*) ejecting a Fledgling Meadow-Pipit from the Nest

inadvertence or any other cause, adopted the habit of casually dropping her eggs in a neighbour's nest, might thereby ensure a profitable inheritance for endless generations of her offspring. This much granted, all the rest will follow easily enough, but it must be confessed that this is only a presumption, though a presumption which seems plausible if not likely."

FISHES (PISCES) AS PARASITES

The Lampreys and Hags (*Cyclostomata*) are scaleless, eel-shaped creatures, devoid of jaws, and intermediate in habit between carnivorous forms and external parasites. On the under side of the head is a bell-shaped sucker, the lining of which is thickened into a varying number of sharp horny teeth. At the top of the bell is the true mouth-opening, provided with a projecting "tongue", also tooth-bearing (fig. 1133). By means of the sucker these creatures are able to attach themselves to other fishes, the flesh of which they rasp away, using the tongue for the purpose, this being moved by means of powerful muscles.

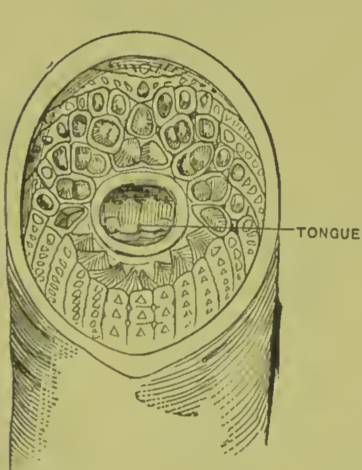


Fig. 1133.—Sucker of a Lamprey (*Petromyzon*)

MOLLUSCS (MOLLUSCA) AS PARASITES

Certain Sea-Snails afford the best illustrations of the parasitic habit as occurring among Molluscs. One of the Cap-Shells (*Thyca ectoconcha*, fig. 1134) is an external parasite upon a kind of Star-Fish (*Linckia multiforis*). It will be seen from the illustration that this form is still easily recognizable as a mollusc, though the influence of its particular mode of life is also obvious. The mouth has shifted backwards, and is on the end of a short proboscis, which penetrates into the body of the host, and is surrounded by an adhesive disc, formed by the fusion of parts of the foot with an outgrowth from the head. The characteristic rasping-organ (odontophore) has entirely disappeared, and the pharynx has been converted into a sort of suction-pump by which the juices of the star-fish are drawn in. The body of the same un-

fortunate star-fish may also present a number of rounded swellings in which are lodged parasitic snails of another species (*Stilaster Linckiæ*) that have undergone much further modification, being practically endoparasites in which the proboscis has become very long, while the rest of the body is much smaller in proportion, and the shell has disappeared. Communication with the exterior is still kept up, however, by means of a small hole, in the interests of breathing and the getting rid of waste products. From this case we pass on to degenerate worm-like snails, which are true internal parasites, and have lost most of the typical organs of the group to which they belong, though the study of their life-histories renders no doubt possible as to their classificatory position. Their bodies hang freely into the interiors of their hosts, one end being fixed to the inner side of the body-wall of the same. A degenerate of the kind (*Entocolax Ludwigii*) lives within a species of sea-cucumber (*Myriotrochus Rinkii*), and one still more strongly modified (*Entoconcha mirabilis*) within another creature of the same sort (*Syapta digitata*).

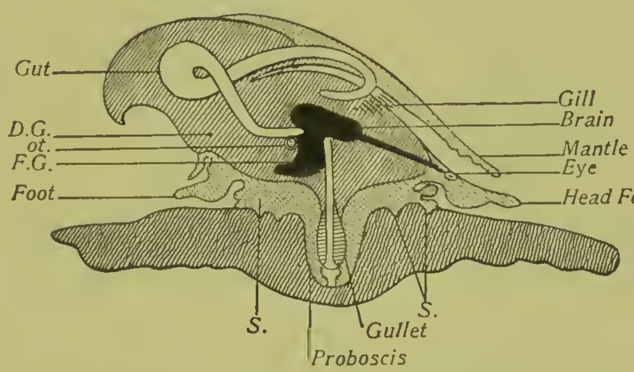


Fig. 1134.—Parasitic Cap-Shell (*Thyca ectoconcha*) attached to the Skin of a Star-Fish (*Linckia multiforis*); diagrammatic section. *D.G.*, Digestive gland; *F.G.*, foot-ganglion; *S.*, *S.*, suctorial disc; *ot.*, otocyst.

The parasitic habit of the larvæ of Freshwater Mussels has been dealt with elsewhere (see vol. iii, p. 406).

INSECTS (Insecta) AS PARASITES

Innumerable insects have adopted the parasitic habit, either for the whole of their lives or for some particular stage of existence. It will only be possible to give a limited number of examples in illustration of the more interesting kinds of adaptation.

Bugs (Hemiptera) as Parasites.—The fact that the insects of this order possess piercing and sucking mouth-parts naturally suggests that some of them attack other animals, which is indeed the case, though the majority would appear to devote themselves

to plants. Where, as largely in Water-Bugs, small creatures are selected as victims, these are killed as a result of the feeding operations, and the true carnivorous habit is illustrated. But Bugs which feed on the blood of relatively large animals may be described as external parasites. The most notable example is the wingless Bed Bug (*Cimex lectularius*), which is fortunately a favourite prey of several other insects, including some belonging to the same order (*e.g.* species of Reduvius). The True Lice, which live entirely upon the blood of Mammals, are very possibly to be regarded as minute Bugs, which have lost their wings and become modified in other ways as a result of the parasitic habit. Considering the mode of life, their small size is clearly an advantage, and their remote ancestors were probably larger insects.

Fig. 1135. — Swallow - Fly (*Stenopteryx hirundinis*) above and Sheep-"Tick" (*Melophagus ovis*) below. The short lines to left show actual length.

Flies (Diptera) as Parasites.—A number of these insects are endowed with mouth-parts adapted for piercing and sucking, and are notable blood-suckers, the habit being commonly restricted to the females. Gnats and Mosquitoes, Midges, Sand-Midges, Breeze-Flies, and Tsetse-Flies, may be cited in illustration. A very interesting series of modifications is found within the limits of one family (*Hippoboscidæ*), which illustrates the reduction of wings resulting from the parasitic mode of life. The feet are provided with strong claws for holding firmly to the animals attacked, and males as well as females are blood-suckers. One of the least modified species is the Forest-Fly (*Hippobosca equina*), which infests horses. Well-developed wings are present, but not much used, as these insects fly unwillingly. Another somewhat similar form (*Lipoptena cervi*) lives on the Red-Deer, and its wings are either shed or bitten off as soon as a host has been secured. The wings of the Swallow-Fly (*Stenopteryx hirundinis*) are small and narrow, while in the so-called Sheep-"Tick" (*Melophagus ovis*) they are altogether absent (fig. 1135). So also in the Bee-"Louse" (*Braula cæca*), a minute insect that infests bees, and some curious little parasites (species of *Nycteribia*) that have been found among the fur of bats.

Some of the insects of this order live within the bodies of

other animals during the early part of their existence, as, *e.g.*, the Bot-Flies (*Œstridæ*), which are only too well known to the owners of stock. The mouth of the adult is greatly reduced, so that there is no question of blood-sucking, while the larvæ do not devour the living substance of their hosts, but absorb the fluid which surrounds them, and is generally a morbid product resulting from the irritation due to their presence. The Horse-Bot (*Gastrophilus equi*, fig. 1136) lays her eggs upon those parts of the horse's body which are easily reached by the tongue, and the young larvæ, when they hatch out, are thus conveyed to the mouth, whence they make their way to the stomach. The head of the maggot is provided with hooks by which it bores into the lining of that organ. In later stages it becomes ovoid

Fig. 1136.—Horse-Bot (*Gastrophilus equi*). 1, Male; 2, female; 3, egg (much enlarged) attached to hair; 4, young larva (enlarged); 5, older larva; 6, empty pupa-case.

in shape, and is known as a "bot". Its powers of adhesion are considerably increased by the presence of circlets of short spines on the body. When a large number of these larvæ are present they set up inflammation, &c., sometimes with fatal results, and they have even been known to bore right through the wall of the stomach. After about nine or ten months the larva looses its hold, and is carried through the digestive organs of the horse to the exterior, where it passes into the motionless pupa stage, from which the adult fly later on emerges.

The eggs of the Sheep-Bot (*Œstrus ovis*) are developed internally, and the female fly deposits the just-born larvæ near the nostrils of the sheep. Thence they pass into the nose, and ultimately into spaces (frontal sinuses) in the bones of the head, where they become "bots". After some nine months' growth these make their way back into the nose, from which they appear to be sneezed out, and pass into the pupa stage. One or two more pests of the kind will be dealt with later, in the section on ANIMAL FOES.

Before leaving the order of Flies, it may be noted that the

wingless blood-sucking Fleas are here included. The modifications which they have undergone have no doubt been in relation to the parasitic habit.

Beetles (Coleoptera) as Parasites and Brood-Parasites.—To this order possibly belongs a family of small insects (*Stylopidæ*) parasitic upon Bees, Wasps, and, to some extent, upon certain Bugs. Many zoologists, however, place them in a distinct order (*Strepsiptera*). The adult female is little more than a shapeless bag, living in the abdomen of a bee or other host, with one end projecting externally (fig. 1137). The adult male, on the other hand, is a very active creature, possessing large hind-wings, but only vestiges of fore-wings. His free life is short, three days being the maximum on record, while in some species (of *Xenos*) fifteen to twenty minutes is the limit, though during this brief period extraordinary energy is shown. The numerous eggs are developed internally, hatching out into minute six-legged larvæ, which make their way into the bodies of bee-grubs or the like, though the way in which these hosts are found is in many cases but imperfectly understood. Their presence in the interior of the grubs does not cause death, for they feed upon the fatty substance (fat-body) between the various organs. Having once become parasitic they lose their legs and assume the appearance of minute maggots. Later on, when the bee-grub passes into the pupa stage, the parasitic larva pushes out one end to the exterior, and, if a male, also passes into the pupa stage, but if a female, undergoes comparatively slight modifications. When the adult bees come out of the pupæ the male parasites also emerge to lead their free existence, but the females remain fixed in their hosts. Individual bees harbour but one or a few of these curious parasites; in wasps they may be more numerous.

Fig. 1137.—A Bee-Parasite (*Stylops aterrimus*), enlarged. The male is shown above, the female (with two contained embryos) below to right, and the larva below to left.

The parasitic habits of some of the Oil-Beetles (*Meloidæ*) are both remarkable and highly interesting. Fabre has worked out the life-history of one species (*Sitaris humeralis*, fig. 1138), of which the larvæ feed on the eggs and honey of certain bees

(*Anthophora*) that make underground nests, storing each cell with honey, and then laying an egg therein. In early autumn the female beetle lays her numerous eggs (as many as 2000) near the openings of bees' nests, and these hatch out into minute six-legged larvæ, which hibernate till the following spring. After the winter-sleep is over these little creatures hold on to any hair-clad insects that pass sufficiently near, and are thus carried away. Only those which have by good fortune attached themselves to the right sort of bee have any chance of surviving, and a great many are undoubtedly transported by unsuitable insects, merely to die. Hence in all probability the reason for the production of so many eggs. Some of the successful larvæ unconsciously select female bees as carriers, but most appear to attach themselves to drones, whence they transfer themselves to individuals of the opposite sex. When one of these female bees lays an egg in a honey-filled cell, a predatory larva immediately transfers itself to the egg, and the bee roofs in the cell. To fall into the honey would be fatal to the larva, but it stands firmly on the floating egg, and thus avoids this danger. This scene in the drama lasts for eight days, the larva being busily employed eating up the nutritious contents of the egg. Moulting now takes place, and the once active robber is transformed into a plump grub with breathing-holes (stigmata) placed in the upper part of its body, so that it can float in the honey without fear of suffocation. The sweet food-supply is exhausted in about forty days, by which time it is mid-July, and the grub next becomes a motionless false-pupa, but without shedding its skin, which remains as a dry covering to the body. The further stages in the life-history may follow immediately, but are usually postponed till the following spring, after a long winter-sleep. In either case the false-pupa assumes once more the form of a grub, the skin, however, being retained as a second dry investment. In about two days the grub becomes a true pupa, from which the perfect insect emerges a month later.

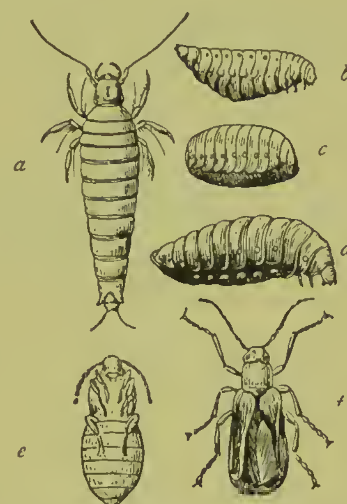


Fig. 1138.—Stages of *Sitaris humeralis*, enlarged. *a*, Six-legged larva; *b*, floating grub; *c*, false pupa; *d*, second grub-stage; *e*, true pupa; *f*, adult beetle.

Some other Oil-Beetles (species of *Meloë*) have much the same

kind of life-history as the form last described, and are parasitic on bees of the same sort. The female beetle does not, however, lay her eggs near a suitable nest, but simply deposits them in the ground. The six-legged larvæ climb up various plants, and commonly lie in wait on or near their flowers, attaching themselves at random to any hairy insects that come near enough. The chances of a given larva reaching a suitable destination are exceedingly small, but as a set-off against this each female beetle lays some 10,000 eggs, which allows for considerable wastage.

MEMBRANE-WINGED INSECTS (HYMENOPTERA) AS PARASITES.—Among the most interesting members of this order in the present connection are the Ichneumon-Flies, and other forms of similar habits, in which the female is provided with a sharp ovipositor,

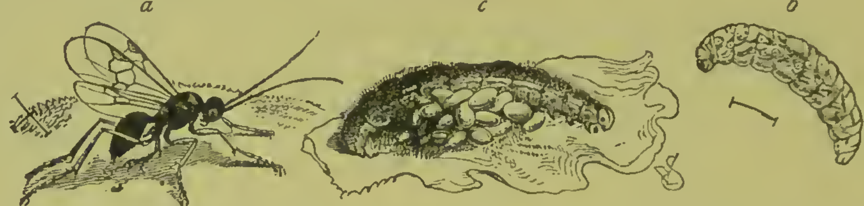


Fig. 1139.—The Yellow-Legged Ichneumon-Fly (*Microgaster glomeratus*). *a*, Adult; *b*, larva; *c*, dead caterpillar of Cabbage-Butterfly, surrounded by cocoons of the Ichneumon. Size of *a* and *b* indicated by the short lines.

by means of which she deposits her eggs within the bodies of the larvæ, pupæ, or even eggs of other insects. In some cases deposition takes place not in, but on or sufficiently near, suitable victims. The early stages of Butterflies and Moths are particularly liable to such attacks, and in this way the ravages of many of our familiar agricultural and garden pests are kept within bounds. Some of these parasites are in turn similarly attacked by insects not distantly related to them, a case of the biter bit. The common Cabbage-Butterfly (*Pieris brassicæ*) is subject to the attentions of a number of these forms. By one (*Polynema gracilis*) its eggs are pierced, two others (*Microgaster glomeratus*, fig. 1139, and *Pimpla instigator*) lay their eggs in its caterpillars, and still another two (*Pteromalus puparum* and *P. pontiæ*) attack its chrysalides.

Certain larvæ and pupæ, that live where one would expect them to be quite secure from these parasitic insects, are nevertheless sought out by them, and exposed to the murderous assaults of their brood. One kind of Ichneumon-Fly (*Agriotypus armatus*) boldly plunges into water, and lays her eggs in the

larvæ of caddis-moths. Others (species of *Rhyssa* and *Thalessa*, fig. 1140) possess powerful ovipositors three or four inches long, with which they penetrate trees tunnelled by the larvæ of wood-wasps (*Siricidæ*). The grubs which hatch out from the eggs of such ichneumons attach themselves as external parasites to the wood-boring larvæ. Fabre has described the even more remarkable habits of another parasitic form (*Leucopsis gigas*), that seeks the nests of the Mason-Bee (*Chalicodoma muraria*), in which a number of cells, each containing a larva, are surrounded by little stones cemented together (see p. 53). The parasite thrusts her stout ovipositor through weak spots in this masonry, never failing to reach the contained cells, in each of which she deposits an egg. It is only when such a cell contains a full-grown bee-larva, on the point of becoming a pupa, that the operation attains the desired object. In this case the parasitic grub first wanders round the cell to destroy any other eggs that may have been there deposited, and then attaches itself to the bee-larva, the juices of which nourish it for two or three weeks. Next follows a quiescent period of ten or eleven months, after which the larva becomes a pupa, from which the perfect insect soon emerges.

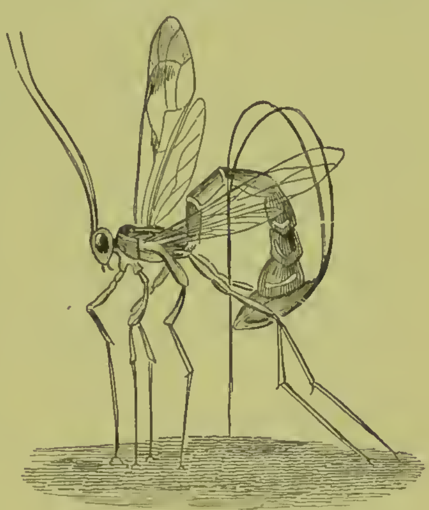


Fig. 1140.—A Female Ichneumon-Fly (*Thalessa*) using her Ovipositor

SPIDER-LIKE ANIMALS (ARACHNIDA) AS PARASITES

Many of the Ticks and Mites (Acarina) are parasitic upon other animals, and some of them have earned considerable notoriety on this account. Ticks are greedy blood-suckers which lurk on plants, and attach themselves to passing birds or mammals, human beings not excepted (fig. 1141). One of the best-known species is the Dog-Tick (*Ixodes ricinus*). A victim once secured, the tick buries its piercing mouth-parts in the skin, and takes in so much blood that it swells visibly. When satiated it drops off, and digests the meal at leisure.

Fig. 1141.—A Tick (*Ixodes*), enlarged

Mange- or Itch-Mites exhibit degrees in parasitism. Some of them (*Dermatophagus*) simply devour the loose scales which are constantly being detached from the epidermis, while others (*Dermatocoptes*) suck blood. But the most objectionable (*Sarcoptes*, fig. 1142), those responsible for the unpleasant disease known as "itch", actually burrow in the skin, within which the female lays her eggs, and may therefore be described as true internal parasites. They live on the blood and other juices of their hosts.

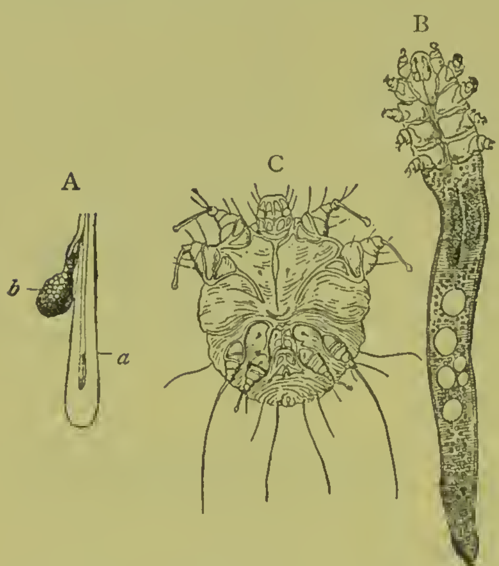


Fig. 1142.—A, Root of hair; (*a*) enlarged, showing a swollen sebaceous gland (*b*), containing a Hair-Mite (*Simonea folliculorum*). B, A Hair-Mite, greatly enlarged. C, An Itch-Mite *Sarcoptes scabei*), greatly enlarged.

A curious little elongated mite (*Simonea folliculorum*, fig. 1142) lives in the little bag-like glands attached to the roots of hair, in which a sort of fatty matter is secreted.

The degenerate Tongue-Worms (*Linguatulida*), which live in the noses oı dogs and wolves, are doubtfully classed with the Arachnida (see vol. i, p. 393).

CRUSTACEANS (Crustacea) AS PARASITES

A large number of the lower Crustaceans are parasitic, and some of them have become extremely degenerate as the result of their mode of life, especially in the case of the females. A few examples must suffice.

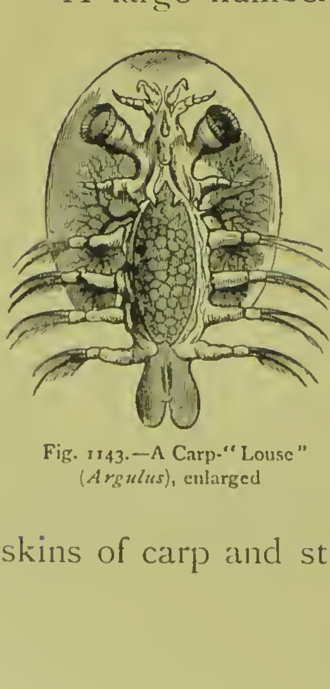


Fig. 1143.—A Carp-"Louse" (*Argulus*), enlarged

Fork-footed Crustacea (Copepoda) as Parasites.—Many of the members of this group are found attached to fishes, usually by means of their suctorial mouths. They are popularly, though somewhat inappropriately, known as Fish-"Lice". Among the least modified kinds are those (*Argulus*, fig. 1143) found attached to the skins of carp and sticklebacks, holding on by a couple of suckers

formed by the modification of parts of two limbs. The piercing jaws are enclosed in a sharp beak-like projection.

A larger amount of modification is found in the female parasite (*Achtheres*) depicted in fig. 1144, and which is not infrequently found attached to the gills or living in the throat of the perch. Creatures of the kind also infest a large number of marine fishes. One (*Lernæa*, fig. 1145) is sometimes found attached to the eye of the sprat, and, as it is phosphorescent, the little fishes which harbour these unwelcome guests are known to fishermen as "lantern sprats".

Fig. 1144.—A Perch-"Louse" (*Achtheres percarum*), enlarged

BARNACLES (CIRRIPEDIA) AS PARASITES.—Some of the members of this group have undergone an extraordinary amount of degeneration as a result of parasitism. This is carried to an extreme in a form (*Sacculina*, fig. 1146) that is sometimes found projecting from the under side of the tail of the Shore-Crab (*Carcinus mœnas*). Only a professed zoologist would suspect it to be a Crustacean, for in appearance it is simply a rounded bag, which dissection shows to be provided with numerous branching root-like threads that grow through the body of the unfortunate host, extending even to the tips of the limbs. A study of its weird life-history (fig. 1146) definitely proves that it is really a distant relative of its unfortunate host. From the egg hatches out a little larva, of the kind (nauplius) typical for lower Crustaceans (see vol. iii, p. 364). After undergoing several moults it assumes a form not unlike that of a mussel-shrimp, and continues to swim about for three days or more. At the end of this period it seeks a very young crab, and fixes itself by means of a feeler to the soft membrane at the base of one of the bristles on a limb or on the back of its victim. The hinder part of its body is then thrown off bodily, and the organs contained in the remainder fuse together into a soft mass. Around this a membrane is developed, part of which becomes converted into a tube that is pushed into the interior of the crab. Through this the soft substance of the parasite squeezes itself. Within the body of its host it migrates to the region of the intestine, in

Fig. 1145.—Sprat-"Louse" (*Lernæa*), enlarged

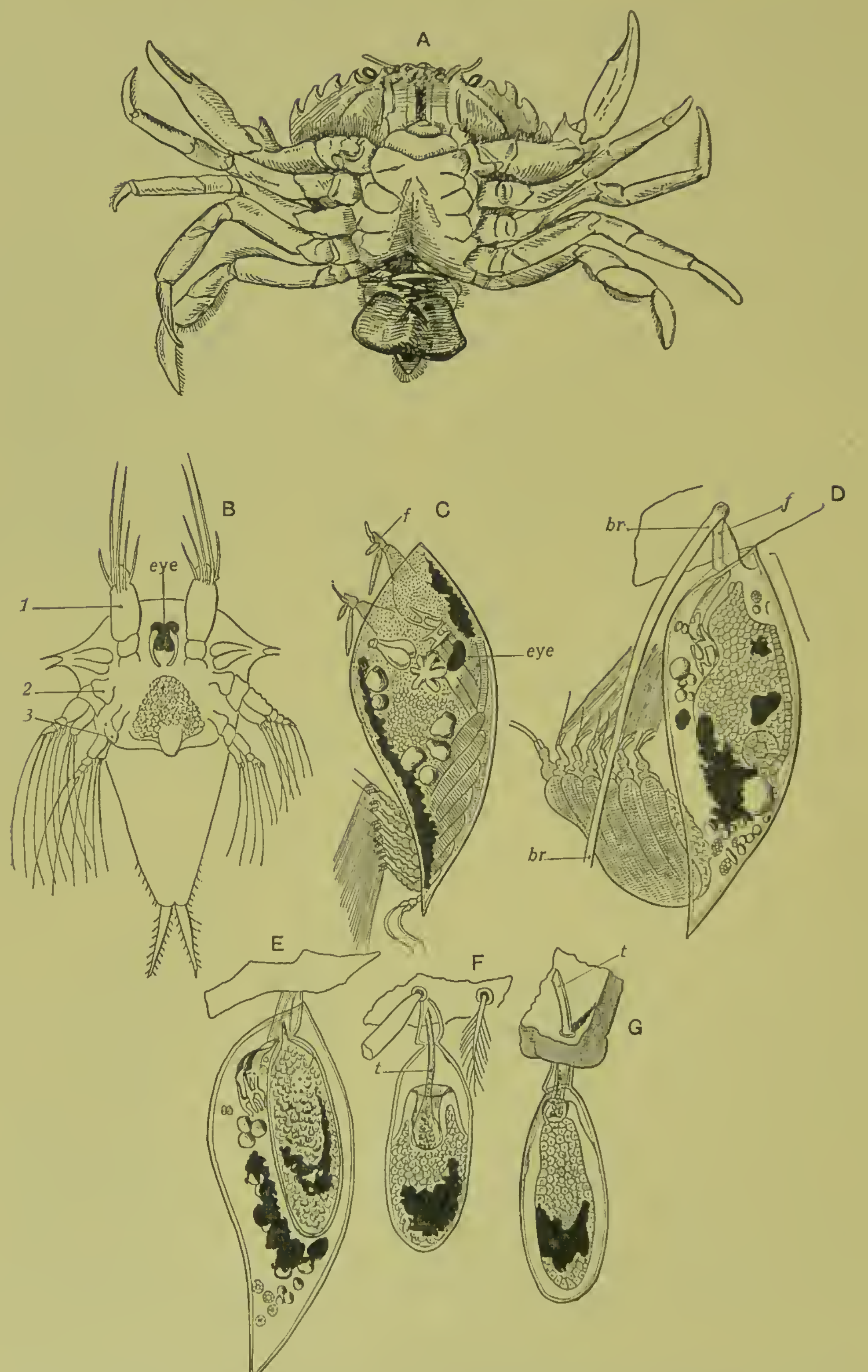


Fig. 1146.—Sacculina. A, Shore-Crab (*Carcinus mænas*), with the parasite projecting from the under side of its tail. B–G, Stages in development, greatly enlarged; B, nauplius stage, with two pairs of feelers (1, 2) and one pair of jaws (3); C, mussel-shrimp stage, showing modified first pair of feelers (*f*); D, the same, attached by one feeler (*f*) to the base of a crab's bristle (*br.*), the hinder part of body is being thrown off; E, F, G, later stages, showing formation of a tube (*t*) through which the soft substance of the parasite passes into the crab.

the neighbourhood of the tail, and root-like threads grow out from it in all directions. Fed by these it grows rapidly, and exerts so much pressure on the muscles and skin which are placed between it and the under side of the tail that they become thinner and thinner. Ultimately, as the final result of this process, the parasite projects to the exterior, its roots, however, remaining inside the crab.

Some of the higher Crustaceans belonging to the group of Slaters (Isopoda) are also parasitic, and have undergone profound modifications.

SEGMENTED WORMS (ANNELIDA) AS PARASITES

We are here concerned with various Bristle-Worms (Chætopoda) and Leeches (Discophora).

BRISTLE-WORMS (CHÆTOPODA) AS PARASITES.—A number of marine worms are external parasites upon hosts of widely different nature, including star-fishes, sea-urchins, sea-cucumbers, corals, and even other annelids. Cases have also been described where one species of marine worm lives parasitically within the body of another species. Much more interesting than these, however, are certain small flattened creatures (e.g. *Myzostoma*, fig. 1147), which live upon, or more rarely within, feather-stars and sea-lilies, sometimes causing gall-like growths that serve as habitations. Since these curious little parasites possess a small number of foot-stumps, each terminating in a pair of bristles, they are probably to be regarded as bristle-worms that have become modified in consequence of their mode of life. And this view is supported by the fact that they begin existence as larvæ which closely resemble those of typical worms of the kind.

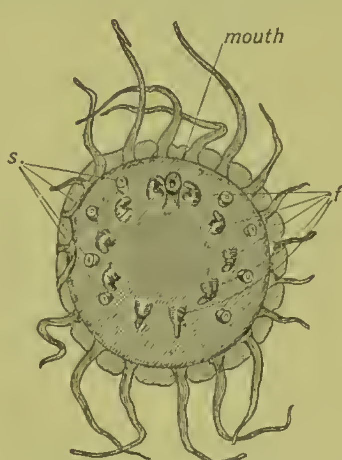


Fig. 1147.—Under Side of *Myzostoma*, enlarged. *s*, Suckers; *f*, foot-stumps.

One large group of Annelids (Few-bristled Worms, *Oligochæta*), of which earth-worms and certain freshwater forms are the typical representatives, includes a small number of species resembling leeches in appearance, as well as in the fact that bristles are entirely absent. They are ectoparasites upon crustaceans, the

Crayfish (*Astacus fluviatilis*), for example, being infested by several of them (species of *Branchiobdella*), which suck its blood and devour its eggs.

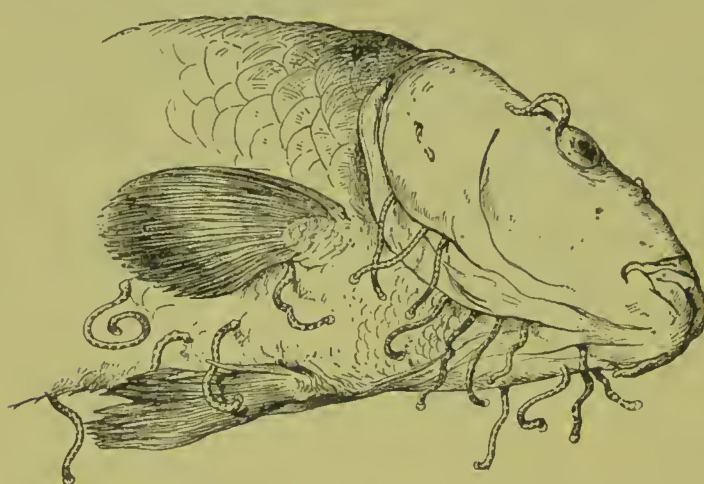


Fig. 1148.—Fish-Leeches (*Piscicola*) attached to the Head of a Carp

LEECHES (DISCOPHORA) AS PARASITES.—While some leeches prey upon animals smaller than themselves, others are true external parasites, and the habits of these have been sufficiently described elsewhere (see vol. ii. p. 147). Some of these creatures (e.g. *Piscicola*, fig. 1148) attach themselves to the exterior of fishes, their presence causing great annoyance or even proving fatal.

FLUKES (TREMATODA) AS PARASITES

The flattened unsegmented animals included in this group are, almost without exception, of parasitic habit. They are provided with organs of adhesion in the form of suckers, and the mouth leads into a muscular pharynx, which serves as a sort of suction-pump by which blood and other substances are taken into the body.

As ectoparasites, flukes are only found upon the bodies of aquatic animals, and in this case three or more suckers are present, since efficient means of holding on are clearly a matter of primary importance. The gills of fishes are particularly liable to such attacks, and it is only natural that this should be so, for their sheltered position, delicate texture, and abundant blood-supply are great advantages, from the parasitic point of view.

We may take as an example a form (*Octobothrium pollachii*, fig. 1149) which lives upon the gills of the pollack, adhering by means of eight stalked suckers. A related species (*O. merlangi*) lives on the whiting, and the herring is infested by a similar parasite, in which, however, the suckers are not stalked. A curious case, where the host is not a fish, is presented by a

minute three-suckered fluke (*Udonella caligorum*), numbers of which attach themselves to the egg-bags of a degenerate crustacean (*Caligus*), living as a parasite upon the gills of the hake.

Aquatic Amphibians do not escape from the attacks of Flukes, a notable instance being afforded by one of these creatures (*Polystomum integerrimum*) which lives, when adult, in the urinary bladder of the frog, and illustrates the transition from external to internal parasitism. It adheres to the lining of the bladder by means of a rounded projection at its hinder end, on which are situated six suckers and many small hooks. The numerous eggs are laid in spring, and pass from the frog's body to the exterior, where they hatch out into minute ciliated larvæ, which actively swim about in search of tadpoles. To understand what happens next, it must be remembered that at a certain stage in development a fold grows back from the head of a tadpole, covering the gill-slits, and uniting with the adjacent skin so as to enclose a gill-chamber opening to the exterior by a small hole or spiracle on the left side. The continued existence of the fluke-larva depends upon its finding a tadpole within twenty-four hours, preferably one in the stage described. If successful in this quest it swims into the gill-chamber through the spiracle, and becomes parasitic upon the gills. After living for two months or so in these comfortable quarters a change of residence becomes necessary, for the tadpole is becoming a frog, the gills are disappearing, and the gill-slits are closing up. The larva now makes its way into the pharynx of its host, and passing through gullet, stomach, and intestines, reaches and enters the bladder, where it becomes adult in about three years.

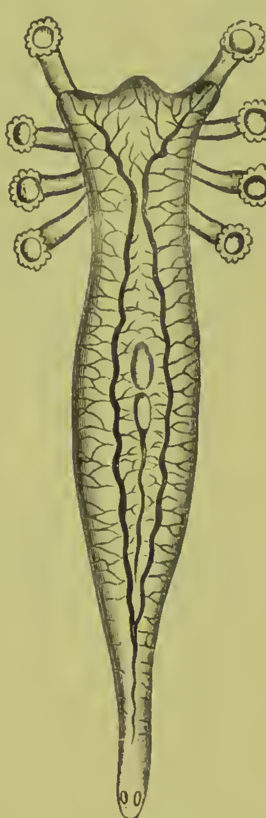


Fig. 1149.—Eight-suckered Pollack-Fluke (*Octobothrium pollachii*), enlarged

Mention must here be made of a singular species of many-suckered Fluke (*Diplozoön paradoxum*, fig. 1150) which lays its eggs upon the gills of the minnow. Minute ciliated larvæ hatch out, which perish in from five to six hours unless they find another host of the same kind. In that case, after further growth, they fuse together in pairs, and become X-shaped adults, capable of

producing eggs. The adult is therefore a compound animal, for each stroke of the X was originally a distinct individual, and has a mouth at one end.

A great many Flukes live in the internal organs of various animals, and differ in several important respects from those already described. There is less occasion for adhesive organs, and the usual number of suckers is two, one surrounding the mouth at the front end of the body, and the other situated upon the under surface. In some cases the latter is absent. Two or three different kinds of host are infested in the course of the life-history, the reason probably being that unlimited increase in the same sort of host might ultimately lead to its exinction, when a similar fate would overtake the parasite. Although the relations existing between the two or three hosts are such as to favour transfer, the chances are greatly against the survival of a given larva, to meet which contingency immense numbers of small eggs are produced, fewer and correspondingly larger eggs being the rule for external parasites attacking but one kind of host. And, as might be anticipated, the life-history is very complicated.

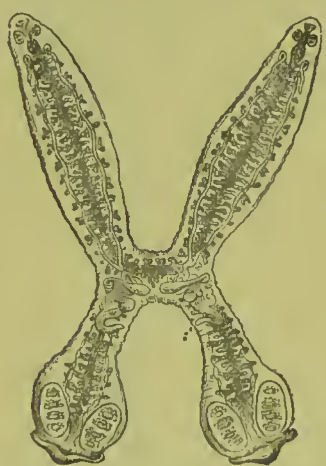


Fig. 1150.—Diplozoön paradoxum

The best-known form is the notorious Liver-Fluke (*Fasciola hepatica*, see vol. i, p. 443), which, when adult, infests the liver of the sheep, producing what is known as "liver rot". To this and other especially injurious species reference will be made later. It will suffice here to describe a form (*Distomum macrostomum*, fig. 1151) in which the life-history is rather simpler, but at the same time of greater interest. This little Fluke, when adult, lives in the intestine of various small birds, such as sparrows, warblers, and tits. Its eggs pass out to the exterior, and many of them get scattered over leaves. If one of them happens to be swallowed by a particular species of small Snail (*Succinea putris*) it hatches out into a minute larva, which bores through the wall of the digestive tube, and penetrates between the organs contained in the body of its host. Being now surrounded by nutritious and easily-absorbed fluid it grows rapidly, becoming converted into a shapeless sac (sporocyst), from which branches are given off in

all directions. Those which lie near the surface of the head, and penetrate into the tentacles, assume a worm-like form, and are brightly coloured with rings of white and green, while the end of each of them is marked with a red spot. These tints are easily seen through the stretched and translucent skin of the snail. The resemblance of these structures to worms is increased by the fact that they expand and contract in a rhythmic way, and they were at one time actually supposed to be a kind of parasitic worm, and received a special name (*Leucochloridium paradoxum*). Attracted by the colours and movement, small birds nip off the tentacles of the snail, the bright-hued tubes of which contain numerous tiny flukes that have developed within them. The fate of these now trembles in the balance, for if they are swallowed by the adult bird itself they are simply digested, but if, on the other hand, they are fed to its nestlings, they are able to develop into adult flukes.

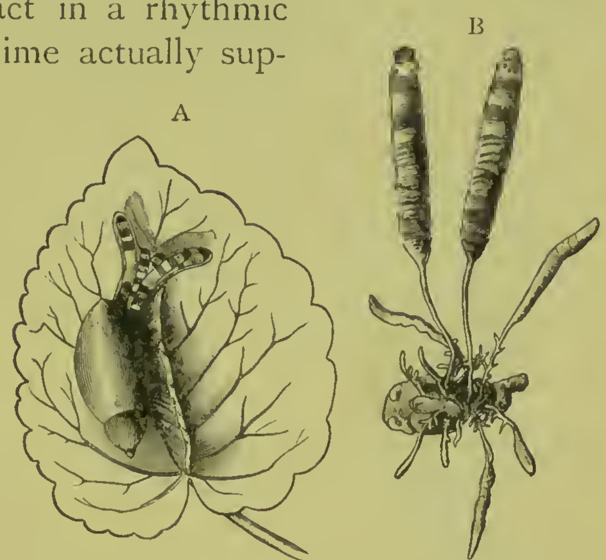


Fig. 1151.—*Distomum macrostomum.* A, A Land-Snail (*Succinea putris*) infested by sporocyst, some of the banded worm-like branches of which can be seen through skin of head and tentacles. B, A sporocyst, enlarged, and showing two worm-like branches.

TAPE-WORMS (CESTODA) AS PARASITES

Creatures resembling Planarian Worms (see vol. i, p. 445) were probably ancestral to Flukes, and they, in their turn, stand in a similar relation to the degenerate internal parasites known as Tape-Worms. In these the peculiar mode of life has had a still more far-reaching influence, for there are no digestive organs, and the nutriment consists either of the fluids or the already digested food of the animals which play the part of hosts. In either case it is absorbed by the general surface of the parasite.

The simplest kind of Tape-Worm known (*Archigetes Sieboldi*, fig. 1152) is a minute creature, less than one-eighth of an inch long, which lives within the body of the small Red River-Worm (*Tubifex*), and there attains the egg-producing stage, which else-

where is only reached within the digestive tube of a backboned animal. It may possibly be a specialized larva, like the Axolotl (see vol. i, p. 249), but our knowledge is too incomplete to justify such a conclusion.

The best-known Tape-worms consist of a head, provided with organs of adhesion, and passing behind into a series of flat joints (proglottides), in which vast numbers of eggs are produced. The complex life-history of the Common Tape-Worm (*Tænia solium*) has been briefly described elsewhere (see vol. i, p. 441). In the adult condition it lives in the intestine of man, sometimes attaining the length of 9 feet, while in an earlier stage it is found encapsuled in the muscles of the pig, producing the disease known as "measles".

Fig. 1152.—A Simple Tape-Worm (*Archigetes Sieboldi*), greatly enlarged

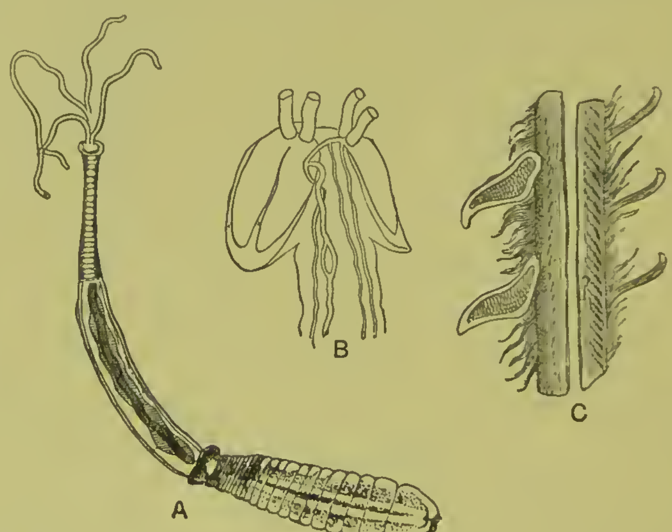


Fig. 1153.—A Fish Tape-Worm (*Tetrarhynchus*). A, Adult worm, enlarged, showing the four proboscides; B, head of same still further enlarged, showing double suckers, and proboscides slightly protruded: C, part of a proboscis, very highly magnified, to show the hooks.

In one small kind of Tape-Worm (*Tetrarhynchus*, fig. 1153) the adhesive apparatus on the head is somewhat complex, consisting of two double suckers, and four tubes studded with numerous hooks. When adult it lives in the intestines of fishes of the shark and ray kind (Elasmobranchii). The life-history of one species has been worked out by Herdman and Hornell, and is of particular interest. In this case the host of the adult worm is a large Ray (*Trygon*), which is common in Indian seas. The eggs pass from the body of the fish, and hatch out into minute active larvæ, which perish unless they succeed in entering the shells of

the Pearl-Oyster (*Margaritifera vulgaris*), a well-known bivalve on account of the pearls which it yields. The Gulf of Manaar, in particular, has been the seat of an important pearl-fishery for between two and three thousand years. Successful larvæ bore into the bodies of the oysters, and undergo further development, attaining the size of a small pin's head. One of the mollusc's enemies is the Trigger-Fish (*Balistes*), and if this swallows an infested oyster the tape-worm embryos bore through the wall of the stomach, and become encapsuled in the body of the fish. The trigger-fish in its turn may be devoured by a sting-ray, in which case the young tape-worms become adult. The life-history of this parasite is therefore passed within the bodies of three distinct kinds of animal, the final host being the most powerful, as usual in such cases. It remains to add that many of the tape-worm embryos die while still within the oysters, and, proving a source of irritation, are covered by successive layers of calcareous matter. It is in this way that the best or "orient" pearls are formed.

THREAD-WORMS (NEMATHELMIA) AS PARASITES

The members of this large group are cylindrical unsegmented worms, most of which are internal parasites in the bodies of animals or plants. They are less degenerate than tape-worms, and the very numerous species differ greatly in respect of the complexity of their life-history, and the hosts infested. One or two of them have already been briefly described (see vol. i, p. 447), and something will be said about others in the section on ANIMAL FOES.

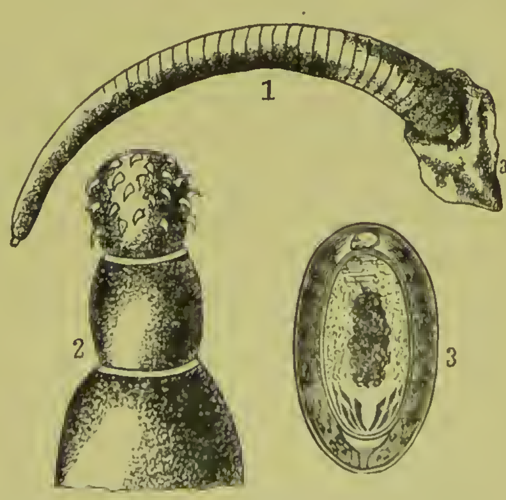


Fig. 1154.—Thorn-headed Worm (*Gigantorhynchus gigas*). 1, A worm attached to the lining (*a*) of a pig's intestine; (2), hooked proboscis of same, enlarged; 3, egg containing an embryo, greatly enlarged.

Some curious internal parasites, the Thorn-headed Worms (*Echinorhynchidæ*), are generally regarded as related to the Thread-Worms, and in them the digestive organs are entirely absent. We may take as an example a form (*Gigantorhynchus*

gigas, fig. 1154), which, when adult, lives in the intestine of the pig, maintaining a firm hold by means of a formidable hollow "proboscis", thickly studded with hooks. The eggs pass out of the body of the pig, and some of them are swallowed by beetle-grubs, within which the development is carried on to a certain stage. If an infested grub happens to be eaten by a pig the life-history of the parasite is completed.

ANIMALCULES (PROTOZOA) AS PARASITES

The large group of Gregarines (Sporozoa) includes typical internal parasites, in which the body is surrounded by a firm elastic membrane, through which the body-fluids or digested food of the host are easily absorbed. A well-known form (*Clepsidrina blattarum*, fig. 1155) infests the intestines of the cockroach. The young parasite is worm-like in shape, and its body is divided into three regions, one of which bears hooks, and serves as a means of adhesion to the host. Later on this part is thrown off, and the gregarine lies freely in the intestine, where it absorbs food, and increases considerably in size. The life-history is somewhat peculiar. Two parasites adhere together, and become enclosed in a firm case or cyst, which is passed out of the body of the host. If the surroundings are sufficiently damp the outer part of the cyst swells up into a gelatinous layer, and complex changes go on in the interior. The bodies of the two contained parasites break up into a large number of minute spores, with firm coats, scattered through a kind of net-work. A number of tubes are also formed which turn inside out, and since they convey the spores out of the cyst are termed *sporoducts*. If these spores are swallowed by a young cockroach their firm coats

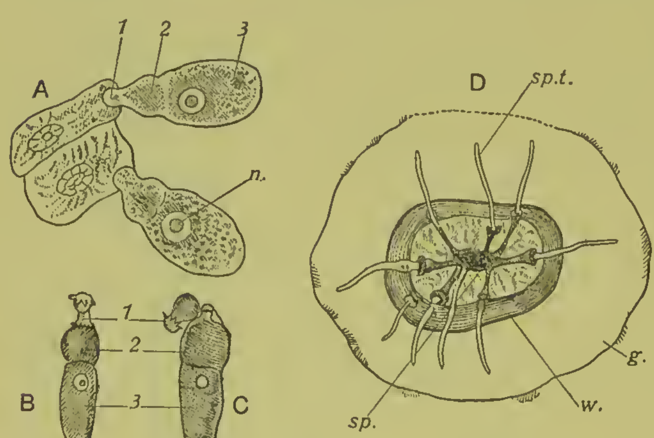


Fig. 1155.—Cockroach Gregarine (*Clepsidrina blattarum*), enlarged to various scales. A, Young gregarines attached to cells of intestine; B and C, later stages lying free within intestine; D, spore-cyst in section. 1, 2, 3, Three body-regions, of which 1 is thrown off by adult; *n.*, nucleus; *g.*, gelatinous covering of cyst; *sp.*, mass of spores in middle of cyst; *sp.t.*, spore-tubes; *w.*, firm wall of cyst.

are dissolved by the digestive fluids, and the soft protoplasmic contents make their way into the cells which line the intestine, there to develop into worm-like gregarines.

A great number of the Sporozoa are excessively minute parasites living within the bodies of hosts of various kinds, and often giving rise to disease. It has been proved, for example, that malarial fever is due to a blood parasite of the kind introduced by the agency of a Mosquito (*Anopheles*). The complex life-history of this form will be briefly given in the section on Animal Foes.

UTILITARIAN ZOOLOGY

CHAPTER LXVII

ANIMAL FRIENDS—ANIMALS AS A SOURCE OF FOOD—DOMESTICATION—DOMESTICATED MAMMALS

The view taken in this work as to the scope of Utilitarian Zoology has been sufficiently indicated in the Introduction (see vol. i, p. 18), and if by no means free from objection, it may serve to marshal important facts and principles in a fairly orderly manner.

Although the feeding habits of Man differ greatly according to the environment, he may fairly be described as omnivorous (see vol. ii, p. 225), but the proportion of animal food taken increases as we pass from tropical and sub-tropical regions into higher latitudes. The commissariat question has necessarily been a dominant factor in the evolution of human civilization, and this is abundantly evident if we recall the oft-told story of that evolution so far as Western Europe is concerned. In this area, as is generally known, there have been successive Ages of Stone, Bronze, and Iron, names indicating the materials employed in making the chief weapons and implements. During the first of these ages prehistoric man passed through the three most important stages marking the progress of civilization, *i.e.* those of (1) the Hunter and Fisherman, (2) the nomad Herdsman and Flock-Master (pastoral stage), and (3) the Tiller of the Soil (agricultural stage). The first two of these (and of course the third) still find parallels among existing races. In an interesting little book by Jenks (*A History of Politics*) the native Australians are taken as an illustration of the first stage:—" The material side of Australian existence may be best described in a series of negatives. The savages understand neither the cultivation of the land nor the rearing of sheep and cattle. Their only domestic animal

(if 'domestic' it can be called) is the dog. . . . They have no food but the scanty game of the 'bush' or forest, such as the wallaby and the opossum, and the natural products of the earth. . . . It is the custom to speak of the Australians and other savages as living in 'tribes'. But the term is most misleading; for the word 'tribe' always suggests to us the notion of descent from a common ancestor, or, at any rate, of close blood relationship. Now there is . . . a most important stage in human progress, in which descent from a common ancestor plays a vital part in social organization. But the Australian 'tribe' does not really play a very important part in savage life, at least on its social side. It appears to be mainly a group of people engaged in hunting together, a co-operative or communal society for the acquisition of food-supply. It would really be better to call it the 'pack'; for it far more resembles a hunting than a social organization. All its members are entitled to a share in the proceeds of the day's chase, and, quite naturally, they camp and live together."

To make a complete list of wild animals that minister to the appetite of mankind would be an unnecessary task, but a brief summary is given in the sequel. Savages in particular are often far from fastidious in such matters. Lord Avebury (in *Prehistoric Times*) compiles from various authorities the following somewhat varied bill of fare of these same Australians:—"The food of the Australian savages differs much in different parts of the continent. Speaking generally, it may be said to consist of various roots, fruits, fungi, shell-fish, frogs, snakes, honey, grubs, moths, birds, birds'-eggs, fish, turtles, dogs, kangaroos, and sometimes of seal and whale. The kangeroo, however, forms only an occasional luxury, nor are the natives, so far as I am aware, able to kill whales for themselves, but when one is washed on shore it is a real godsend to them. Fires are immediately lit to give notice of the joyful event. Then they rub themselves all over with blubber, and anoint their favourite wives in the same way; after which they cut down through the blubber to the beef, which they sometimes eat raw, and sometimes broil on pointed sticks. As other natives arrive, they 'fairly eat their way into the whale, and you see them climbing in and about the stinking carcase, choosing titbits'. For days 'they remain by the carcase, rubbed from head to foot with stinking blubber, gorged to repletion with putrid meat —out of temper from indigestion, and therefore engaged in con-

stant frays—suffering from a cutaneous disorder by high feeding—and altogether a disgusting spectacle. There is no sight in the world more revolting than to see a young and gracefully-formed native girl stepping out of the carcase of a putrid whale' (Gray's *Explorations in North-West and Western Australia*). The Australians also mash up bones and suck out the fat contained in them. Like other savages, they are excessively fond of fatty substances."

To illustrate a predominatingly animal diet we may take the following *menu* of an Esquimaux feast, given by comparatively civilized individuals:—" A factor being invited to a great entertainment with several topping Greenlanders counted the following dishes:—1. Dried herrings. 2. Dried seal's flesh. 3. Boiled ditto. 4. Half-raw and rotten ditto, called mikiak. 5. Boiled willocks [sea-birds]. 6. A piece of a half-rotten whale's tail (this was the dainty dish or haunch of venison to which the guests were properly invited). 7. Dried salmon. 8. Dried reindeer venison. 9. A dessert of crowberries mixed with the chyle out of the maw of a reindeer. 10. The same, enriched with train oil." (Crantz—*History of Greenland.*) It may be added that blood is a favourite Esquimaux drink.

Even among civilized nations fish and molluscs are important articles of food, and it is interesting to know that this was also the case during the Stone Age. Along the shores of Denmark and many other countries, including Britain, are to be found, more or less abundantly, shell-mounds or "kitchen-middens" (Danish *kjökkenmöddings*), the sites of many a prehistoric meal. In Danish mounds the shells of oysters, cockles, mussels, and periwinkles are by far the most abundant, and with them are associated the bones of fishes (herring, dab, eel, &c.), birds, (capercailzie, duck, swan, goose, &c.), and mammals (deer, wild boar, &c). Remains of domesticated animals are entirely absent, except of the dog, and many of the bones have been gnawed by this half-wild attendant at the feasts. Darwin's account (in *A Naturalist's Voyage*) of some of the inhabitants of Tierra del Fuego furnishes a modern parallel to the kind of life led by the prehistoric men of the shell-mounds, except that the latter were probably in better case. He says:—" The inhabitants, living chiefly upon shell-fish, are obliged constantly to change their place of residence; but they return at intervals to

the same spots, as is evident from the piles of old shells, which must often amount to many tons in weight. . . . These poor wretches were stunted in their growth, their hideous faces daubed with white paint, their skins filthy and greasy, their hair entangled, their voices discordant, and their gestures violent. Viewing such men, one can hardly make one's self believe that they are fellow-creatures, and inhabitants of the same world. It is a common subject of conjecture what pleasure in life some of the lower animals can enjoy. How much more reasonably the same question may be asked with respect to these barbarians! At night, five or six human beings, naked, and scarcely protected from the wind and rain of this tempestuous climate, sleep on the wet ground, coiled up like animals. Whenever it is low water, winter or summer, night or day, they must rise to pick shell-fish from the rocks; and the women either dive to collect sea-eggs, or sit patiently in their canoes and, with a baited hair-line without any hook, jerk out little fish. If a seal is killed, or the floating carcase of a putrid whale discovered, it is a feast; and such miserable food is assisted by a few tasteless berries and fungi."

WILD ANIMALS AS A SOURCE OF FOOD

MAMMALS (MAMMALIA).—The large majority of the members of this class, from the Spiny Ant-Eater (*Echidna*) and the Duck-Bill (*Ornithorhynchus*) of Australia up to Man, are, or have been, used as food. As to the two first, it will be seen from the following remarks made by Semon (in *In the Australian Bush*) in regard to Queensland, that even uncivilized races have marked preferences in the matter of diet, when not under stress of famine:—"My blacks were hardly able to furnish me with any information as to the customs of this animal, *i.e.* the Duck-Bill, which they called 'Jungjumore', for they despise its flesh, and consequently never hunt it. In fact, it has an 'ancient and fish-like smell', even after it has been skinned. The blacks showed utter contempt for 'jungjumore', and could hardly be brought to help me in digging up their burrows or to trouble themselves in any way about this, to their minds, useless and inferior creature. The taste for Echidna is quite the reverse, since their regard for it amounts almost to adoration, and they

consider its flesh a first-rate dainty, superior even to beef, which is the greatest compliment they can pay to any food. According to Bennett, the blacks near the Wollondilly and Yas rivers in New South Wales have a different taste, and are very partial to Ornithorhynchus." The *Pouched Mammals* (*Marsupialia*) of Australia have naturally been largely eaten by the natives, and the Kangaroo, at any rate, is decidedly palatable. Semon says of it, in the work just quoted:—"The muscular tail of the kangaroo furnishes a delicious soup, and its flesh is not to be despised".

Hoofed Mammals (*Ungulata*), especially Ruminants, are more important than any others as a source of food, and this is the primary reason why they have been so largely domesticated. Elephants (*Proboscidea*) have been in times past of great importance to the African larder. Sir Samuel Baker remarks (in *Wild Beasts and their Ways*):—"There is no animal that is more persistently pursued than the elephant, as it affords food in wholesale supply to the Africans, who consume its flesh, while the hide is valuable for shields; the fat when boiled is highly esteemed by the natives, and the ivory is of extreme value. No portion of the animal is wasted in Africa, although in Ceylon the elephant is considered worthless, and is allowed to rot uselessly upon the ground where it fell to die." Of *Gnawing Mammals* (*Rodentia*), Hares and Rabbits have always been most esteemed, while *Insect-eating Mammals* (*Insectivora*) are of no particular importance, though gipsies appear to relish the Hedgehog (*Erinaceus*). The related Bats (*Chiroptera*) are not in much favour, but Fruit-bats (*Pteropus*) are eaten by the Malays.

Flesh-eating Mammals (*Carnivora*) inhabiting the land are less useful as a source of food than most other Mammals, though the omnivorous Bears, and to some extent Dogs, must be excepted. It would appear, in some cases at least, to be a matter of prejudice. Wallace found Jaguar steaks good eating, and this suggested to him the following remarks:—"It appears evident to me that the common idea of the food of an animal determining the quality of its meat is quite erroneous. Domestic poultry and pigs are the most unclean animals in their food, yet their flesh is highly esteemed, while field-rats and squirrels, which eat only vegetable food, are in general disrepute." There can be no doubt that the Cat is good eating, and, under numerous

aliases, it is said to figure in the dietary of various European nations. Simmonds (in *Animal Products*) thus speaks of the culinary value of the Lion:—"The flesh of the lion is eaten by the Hottentots; and a tribe of Arabs between Tunis and Algeria, according to Blumenbach, live almost entirely upon it when they can get it. When a lion has been killed and the skin removed, the flesh is divided, and the mothers take each a small piece of the animal's heart and give it their male children to eat in order to render them strong and courageous. They take away as much as possible of the mane, in order to make armlets of it, which are supposed to have the same effect. It would seem from the journal of the Marquess of Hastings, that this superstition as to eating lion's flesh is as strong in India. On the death of a lion it is stated: 'Anxious interest was made with our servants for a bit of the flesh, though it should be the size of a hazel-nut. Every native in the camp, male or female, who was fortunate enough to get a morsel, dressed it and ate it. They have a thorough conviction that the eating a piece of lion's flesh strengthens the constitution incalculably, and is a preservative against many particular distempers. This superstition does not apply to tiger's flesh, though the whiskers and claws of that animal are considered as very potent for bewitching people.' But the flesh of lions has also been eaten with gusto by Europeans, for Madame Bedichon in her work on Algeria states, that at Oran a lion was killed which three days before had eaten a man, and the prefect gave a grand dinner, the principal dish being the lion, which the French gentlemen assembled ate with the greatest relish. More recently still . . . a magnificent quarter of lion, shot in the neighbourhood of Philippeville, Algeria, by M. Constant Cheret, was sent to the Restaurant Magny, Paris, and served up to a party of nineteen guests, who enjoyed with gusto 'Estouffade de lion à la Méridionale' and 'Cœur de lion à la Castellane'." Among aquatic Carnivores the Seals are valuable as a source of food to Esquimaux and other tribes inhabiting cold latitudes.

Of other aquatic Mammals used as food may be mentioned the Manatees (*Manatus*) and Dugongs (*Halicore*), which constitute the order of *Sea-Cows* (*Sirenia*); while reference has already been made (p. 209) to Whales (*Cetacea*) in this connection.

Birds (Aves).—Birds are eaten even more indiscriminately than Mammals, though birds of prey and fish-eating forms are avoided. The eggs of some wild birds, *e.g.* Plovers, are esteemed a delicacy. Edible birds'-nests have been mentioned elsewhere (see vol. iii, p. 462).

Reptiles (Reptilia).—The high reputation of the Green Turtle (*Chelone mydas*) is familiar, and other members of the same order (*Chelonia*) are also eaten in various parts of the world, besides which the eggs of such creatures may also figure as an article of diet.

Some of the larger *Lizards* (*Lacertilia*) are regularly used as articles of food, especially the Iguanas (*Iguanidæ*) of America and the Water-Lizards (*Varanidæ*) of South and South-East Asia.

To a less extent *Crocodiles* and *Alligators* (*Crocodilia*) and *Snakes* (*Ophidia*) serve as a source of food.

Amphibians (Amphibia).—The only members of the group of importance in this connection are some of the Frogs, which are eaten in India and Europe. In the latter case it is the Edible Frog (*Rana esculenta*) that falls a victim.

Fishes (Pisces).—Fishes are, and always have been, of great importance as a source of food. A very large number are regularly eaten, and it will be most convenient to deal with these in a special chapter.

Molluscs (Molluscs).—Many kinds of shell-fish are used as food, and some of the more important, *e.g.* the Oyster, will be dealt with separately.

Cuttle-fishes, Squids, and Octopods (*Cephalopoda*) are eaten in various parts of the world, particularly by the Chinese and Japanese, while one species (*Eledone*) is a common article of diet in South Europe, nor is it the only one.

Of *Snails and Slugs* (*Gastropoda*) utilized as food by Europeans many examples might be given. The commonest marine form thus employed is probably the Periwinkle (*Littorina*), and after this come Whelk (*Buccinum*), Limpet (*Patella*), and the Ormer or Sea-Ear (*Haliotis*). But there are many more, and in other parts of the world the list is much larger. The marine slug known as the Sea-Hare (*Aplysia*) is eaten in the South Sea Islands.

Land Snails (species of *Helix*) are largely used on the Continent, and to some extent in Great Britain.

Bivalve Molluscs (*Lamellibranchia*) are more important as a source of food than shell-fish of other kinds. Besides Oysters, Cockles, and Mussels there are the esteemed "Clams" of North America (species of *Mya*, *Mactra*, and *Venus*), and Razor-Shells (*Solen*) are also appreciated. The last are known in Scotland as "Spout-Fish", on account of the jet of water they squirt out when disturbed. On the Ayrshire coast the "hunting of the Spout-Fish" is pursued with great zeal at certain times of the year, a pointed instrument being thrust between the valves. These molluscs burrow obliquely in the sand with great rapidity, and are easily alarmed by the approach of footsteps, so there is considerable room for skill in their capture. Other bivalves commonly used for food are Piddocks (*Pholas*), Date-Shells (*Lithodomus*), and Ark-Shells (*Arca*). But the list might be extended almost indefinitely.

Among *Primitive Molluscs* (*Amphineura*) Cooke (in *The Cambridge Natural History*) says of the Mail-Shells (*Chiton*):—"West Indian negroes eat the large chitons which are abundant on their rocky coasts, cutting off and swallowing raw the fleshy foot, which they call 'beef', and rejecting the viscera".

Insects (Insecta).—Bees (*Apis*) as a source of honey are most prominent here, but they will be noticed in a later section. Next to these, Locusts are perhaps of greatest importance, but Ants and Termites are also eaten. The Malays appreciate Cicadas or Tree-Bugs, and by rhythmic hand-clappings are able to lure them down from among the branches. Some of the Scale-Insects (*Coccidæ*) secrete sweet or waxy substances, and regarding one such species Sharp says (in *The Cambridge Natural History*):—"The manna mentioned in the book of Exodus is pretty certainly the honey-dew secreted by *Coccus* (now *Gossyparia*) *mannifera*, which lives on *Tamarix* in many places of the Mediterranean basin. This substance is still called by the Arabs 'man', and is used as food; in its natural state it is a substance very like honey; it is doubtless excreted by the *Coccus*, and is not produced directly by the *Tamarix* as some have supposed." Livingstone mentions a peculiar "kungu cake" eaten by the natives on the shores of Lake Nyassa, and which is made by compressing the bodies of vast numbers of the aquatic larvæ of gnats and related insects.

Centipedes and Millipedes (Myriapoda).—These are men-

tioned here merely as a matter of curious interest. Sinclair remarks as follows (in *The Cambridge Natural History*):—"It is hard to believe that any human being could under any circumstances eat Centipedes, which have been described by one naturalist as 'a disgusting tribe loving the darkness'. Nevertheless, Humboldt informs us that he has seen the Indian children drag out of the earth Centipedes eighteen inches long and more than half an inch wide and devour them. This, I believe, is the only account of human beings using the Myriapoda as food, if we except the accounts of the religious fanatics among the African Arabs, who are said to devour Centipedes alive; though this is not a case of eating for pleasure, for the Scolopendras are devoured in company with leaves of the prickly pear, broken glass, &c., as a test of the unpleasant things that may be eaten under the influence of religious excitement."

Crustaceans (Crustacea).—This group is of obvious importance as a source of food, as the mention of Crab, Lobster, Prawn, and Shrimp is enough to show. A few details will be given in a later section, and it is enough to say here that a very large number of species are eaten in one country or another. One would scarcely expect Barnacles to be used in this way (though they are often mentioned in old accounts of shipwrecks), but certain species are exposed for sale in Spain and South America.

Bristle-Worms (Chætopoda).—The only marine Annelid used to any great extent as human food is the Palolo Worm (*Palolo viridis*) in the Samoa and Fiji islands. The chief facts regarding it are thus summarized by Benham (in *The Cambridge Natural History*):—"The worm . . . . lives in fissures among corals on the reefs, at a depth of about two fathoms. At certain days in October and November they leave the reefs and swim to the shores of the above islands, probably to spawn; and this occurs on two days in each of the above months—the day on which the moon is in her last quarter, and the day before. The natives, who call the worm 'Mbalolo', give the name 'Mbalolo laili' (little) to October, and 'Mbalolo levu' (large) to November, thereby indicating the relative abundance of the worms in these two months. The natives eat them either alive or baked, tied up in leaves; and they are esteemed so great a delicacy that presents of them are sent by the chiefs who live on shore

to those living inland." Another worm, of which the habits are much the same, abounds on the shores of Mota Island, in the New Hebrides, and is also eaten.

Hedgehog-Skinned Animals (Echinodermata).—The "roe" of *Sea-Urchins* (*Echinoidea*) was prized as a luxury by the ancient Romans, and is still eaten on the shores of the Adriatic, as well as in other parts of the world. The "sea-eggs" mentioned in the quotation from Darwin's account of the Fuegians given at the beginning of this chapter (p. 211) are animals of the kind. The collection of sea-urchins (chiefly *Hipponoe esculenta*) for food is an important but decaying industry in Barbados, amounting in value to £4000 per annum.

The dried bodies of *Sea-Cucumbers* (*Holothuroidea*) constitute what is commonly known to commerce as *Bêche-de-Mer* or Trepang, an important article of food to the Chinese. The most extensive fishery is on the Great Barrier Reef of Australia, the annual return of which is worth some £23,000 to Queensland. These animals abound in the West Indies, of which the marine resources are not sufficiently developed. One desideratum is a properly-organized trepang fishery.

Zoophytes (Cœlenterata).—This group of animals is unimportant as a source of food, but Sea-Anemones (*cul de mulet*) are eaten in France, Sicily, and along the shores of the Adriatic.

DOMESTICATION OF ANIMALS

The domestication of certain animals by man has been one of the most important factors in the evolution of civilization, enabling the prehistoric huntsmen and shore-dwellers to pass into the more civilized pastoral stage, from which gradual transition is easy to the still more civilized agricultural stage.

Although the Dog can claim to be the earliest domesticated animal, our greatest debt is obviously due to various Hoofed Mammals (Ungulata), which include all the larger inhabitants of our farmyards, the Camels of the Old World, and the Llamas of the New, while Elephants belong to an order which is not distantly related. The most important domesticated birds belong to two orders, (1) Ducks and Geese (Anseres), and (2) Game-Birds (Gallinæ), including, more particularly, Fowls (descended from an Indian stock) and Turkeys (natives of North America).

One Insect, too, the Honey-Bee (*Apis mellifica*), has played no mean part in the drama of human civilization, and to this may be added the Silk-Worm (*Bombyx mori*) and the Cochineal Insect (*Coccus cacti*).

The following remarks on the origin of Domestication and some of its results are quoted from Jenks (*A History of Politics*):—"The art of taming wild animals and making them serve the purposes of man, is one of the great discoveries of the world. . . . But as to the man or men who introduced it we have no knowledge, except through vague and obviously untrustworthy tradition. . . . In all probability the discovery was made independently by many different races, under combinations of favourable circumstances. But if we cannot speak with confidence of names and dates in the matter, we can make certain tolerably shrewd guesses as to the way in which domestication of animals came about. We start with the fact that the most valuable of the world's domestic animals—the sheep, horse, ox, goat, &c.—are known to exist, or to have existed, in a wild state. It is practically impossible to suppose that these wild animals are (except in rare cases) the result of the escape from captivity of tame animals. It follows, therefore, that the start which a pack of savages could obtain in the matter of domestication would depend upon the character of the wild animals in the neighbourhood. For it is fairly obvious by this time that many wild animals are not suitable for taming. Thus, it is hardly possible that the lion, tiger, or bear will ever really become domestic animals, in spite of the fact that their strength and endurance would prove valuable qualities if they could be used. And so some peoples may have remained utterly savage because of the fact that their country does not produce animals capable of domestication. Again, some races, like the Eskimos, appear to have had only the wild ancestors of the dog and the reindeer (fig. 1156), and thus to have been very limited in their opportunities. Other races have been able to tame the sheep, one of the most valuable aids to civilization; others, again, have had the still more valuable ox. But still the question remains—how was the process of domestication discovered? Here, again, we can only proceed by speculation; but a most valuable account of his experiences in Southern Africa (Damara Land), published by the late Sir Francis Galton in the middle of last century, affords us some suggestive hints

(*Narrative of an Explorer in Tropical South Africa*). . . . Two of the most striking features of the savage character are *recklessness* and *greed*. Being quite unable to make provision for the future, or even to realize the wants of the future, the savage consumes in disgusting orgies the produce of a successful hunt. A stroke of luck, such as the capture of a big herd of game, simply means an opportunity for gorging. But even the savage capacity for food has its limits; and, in exceptionally good

Fig. 1156.—Reindeer (*Rangifer tarandus*)

seasons, there is a superfluity of game. A civilized man would strain every nerve to store the surplus away against future wants. The savage simply wastes it; partly because he knows that meat will not keep, partly because he cannot realize the needs of the future. The 'pemmican' or sun-dried meat of the Red Indian, and his 'caches' or buried hoards, are the limits of the savage capacity for storing up against a rainy day. But if the savage is reckless and greedy, he is often affectionate and playful. If he has had as much food as he can eat, he will amuse himself by playing with his captives instead of killing them. At first, no doubt, there is a good

deal of the cat and the mouse in the relationship; but in time the savage comes positively to love his captives, and even to resist the pangs of hunger rather than kill them. In other words, the earliest domestic animals were *pets*; preserved, not with a view to profit, but for sport or amusement. And it is most important to observe that animals so selected would naturally be the handsomest and finest of the catch, whose appearance would delight the eye. . . . But, of course, feelings of affection would be bound to give way in the long run to feelings of hunger, and then the tame animals would be slaughtered for food. And so it would ultimately dawn on the savage that the keeping of pets was really a profitable business, because it afforded some protection against famine. Gradually it would become more and more common. Finally, the savage would learn by experience that, even without destroying them, his pets could be put to valuable use. Thus the wool of sheep, the hair of goats, the milk of cows, would be to a savage like a gift from an unknown Power. . . . But, when he had got thus far, the savage would have ceased to be a savage; he would have become a *pastoralist*. . . . And then, as all the advantages of the rearing of animals come to be realized, the savage 'pack' gradually changes into a society of shepherds or herdsmen, in which the men are engaged in tending cattle, sheep, or goats, while to the women fall the subordinate offices of spinning the wool, milking the cows and goats, and making the butter and cheese. The men drive the flocks to pasture and water, regulate the breeding, guard the folds against enemies, decide which of the animals shall be killed for food, and break in the beasts of burden." The nomad tribes of the Asiatic steppes, Kirghiz, Kalmucks, &c., are still in the pastoral stage.

A brief account of some of the chief domesticated animals may now appropriately follow.

DOMESTICATED MAMMALS (MAMMALIA) AND THEIR USES

THE DOG (*Canis familiaris*).—It is not likely that the some 180 breeds of Dog which exist at the present day (figs. 1157 and 1158) have all descended from the same wild stock. Various kinds of Wolf, Jackal, and Wild Dog have more probably been domesticated at various times by different races, and the

Fig. 1157.—Greyhound

very wide distribution of the family (*Canidæ*) to which such creatures belong lends probability to this view. We have already

Fig. 1158.—Dachshund

seen (p. 217) that it was the first animal tamed by Man. At a much later period, the monuments of Assyria and Egypt afford

evidence, as Darwin says that (in *Animals and Plants under Domestication*), "four or five thousand years ago, various breeds, viz. pariah dogs, greyhounds, common hounds, mastiffs, house-dogs, lap-dogs, and turnspits, existed, more or less closely resembling our present breeds. But there is not sufficient evidence that any of these ancient dogs belonged to the same identical sub-varieties with our present dogs" (fig. 1159). Although Australia is singularly lacking in higher Mammals, it nevertheless possesses a kind of dog, the Dingo (*Canis dingo*), probably introduced by human agency at a remote period. Friend and companion, guardian of flocks, and protector of the home, no animal has been so closely and so long associated with man as the Dog.

Fig. 1159.—Types of Ancient Egyptian Dogs. A, Turnspit; B, House Dog; C, Hunting Dog.

The CAT (*Felis domestica*).—Here again we have almost certainly to do with an animal of multiple origin, the Wild Cat (*Felis catus*) of Europe and North Asia being probably not the chief ancestor. On this point Beddard (in *The Cambridge Natural History*) speaks as follows:—"The domestic cat is, in fact, regarded as the descendant of the Eastern *F. caffra*, or (perhaps *and*) the closely allied *F. maniculata* (fig. 1160). It is highly probable, however, that after its introduction into this country as a domestic animal it has interbred with the Wild Cat. Many allied species of Cats will interbreed, even two so far apart as the Lion and the Tiger. There are interesting archæological and linguistic reasons for regarding the Domestic Cat as an importation. The legend of Dick Whittington's Cat points to it being a rare and valuable animal, which a tamed *F. catus* would not at that time have been. There was an enactment in Wales against him who should kill the king's Cat, again suggestive of its rarity and consequent value. The very name 'Puss' is a hint of a foreign origin. Some would derive it from Perse, and upon this is based the notion that the

Cat is from Persia. But it seems that Puss is the same as Pasht and Bubastis, showing so far an Egyptian origin for the animal. The ancestral Cats mentioned above are native of Egypt." So far as we know the ancient Egyptians were the first to discover the domestic virtues of this animal, and Herodotus tells us that they treated it with no little consideration (though it scarcely ranked so high as the dog):—"When a fire breaks out a wonderful thing happens to these animals; for the Egyptians, heedless of extinguishing the flames, stand in a line to take care

Fig. 1160.—Fallow Cat (*Felis maniculata*)

of the cats; but those creatures, slipping in between the men, or leaping over them, rush into the fire; and when that happens deep grief seizes the Egyptians. If in any house a cat dies naturally, all the inmates shave merely their eyebrows: those in whose house a dog happens to die, shave the whole of their bodies and heads. The dead cats are taken to some sacred buildings in Bubastis, where, when embalmed, they are buried. With respect to the dogs, they bury them in sacred repositories, each in his own town."

It is not proposed to refer to Kipling as a zoological authority, but those who have not done so (if such exist) should read the story of domestication in "The Cat that Walked by Himself", as a brilliant *tour de force* of imagination (in *Just So Stories*).

In the same place he neatly hits off the mental difference between Puss and the Dog Binkie:—

"Pussy will rub my knees with her head,
  Pretending she loves me hard;
But the very minute I go to my bed,
  Pussy runs out in the yard.
And there she stays till the morning-light,
  So I know it is only pretend;
But *Binkie*, he snores at my feet all night,
  And he is my Firstest Friend!"

Oxen (Bos) and Buffaloes (Bubalus).—The domesticated cattle of various parts of the world are no doubt, like the dogs.

Fig. 1161.—Hungarian Oxen

descended from several wild stocks, and some of them would seem to represent a mixture of strains. The two most notable oxen that appear to have been domesticated in Europe during the Newer Stone Age (Neolithic period) were the great Urus (*Bos primigenius*), and a second much smaller species (*B. longifrons*). It is often considered that the wild White Cattle of Chillingham Park are the direct but dwarfed descendants of the former, while the small dark cattle of Wales and the Scottish Highlands can

probably be traced back to the latter. And we have also to take into consideration the European Bison or Aurochs (*Bison Europæus*), a large and savage form now only surviving in parts of Russia, especially in the Lithuanian forest of Bielovege, where it is jealously preserved. This is not the place to consider in detail how far the various breeds of European Oxen (*Bos taurus*) take origin from one or more of the forms just mentioned, or from still others, for the subject is still in the controversial stage. It need only be stated that even in prehistoric times there were

Fig. 1162.—Dwarf Zebus of Ceylon

several domesticated breeds, while now there are a great many. The large pale Hungarian cattle with their formidable horns are amongst the most remarkable (fig. 1161).

Humped Cattle were domesticated by the ancient Egyptians, and we find them still both in Africa and South Asia, under the name of Zebus (*Bos Indicus*, fig. 1162). Their ancestry is doubtful, and it is also a moot point as to whether or no the race of them living in North-East Africa has contributed a strain to certain European breeds. The curious little grunting long-haired Yak (*Bos grunniens*), characteristic of Tibet, is probably quite distinct. Further India possesses another kind of humped ox, the Gayal (*Bos frontalis*).

Differing in many ways from oxen is the tame Buffalo (*Bubalus*

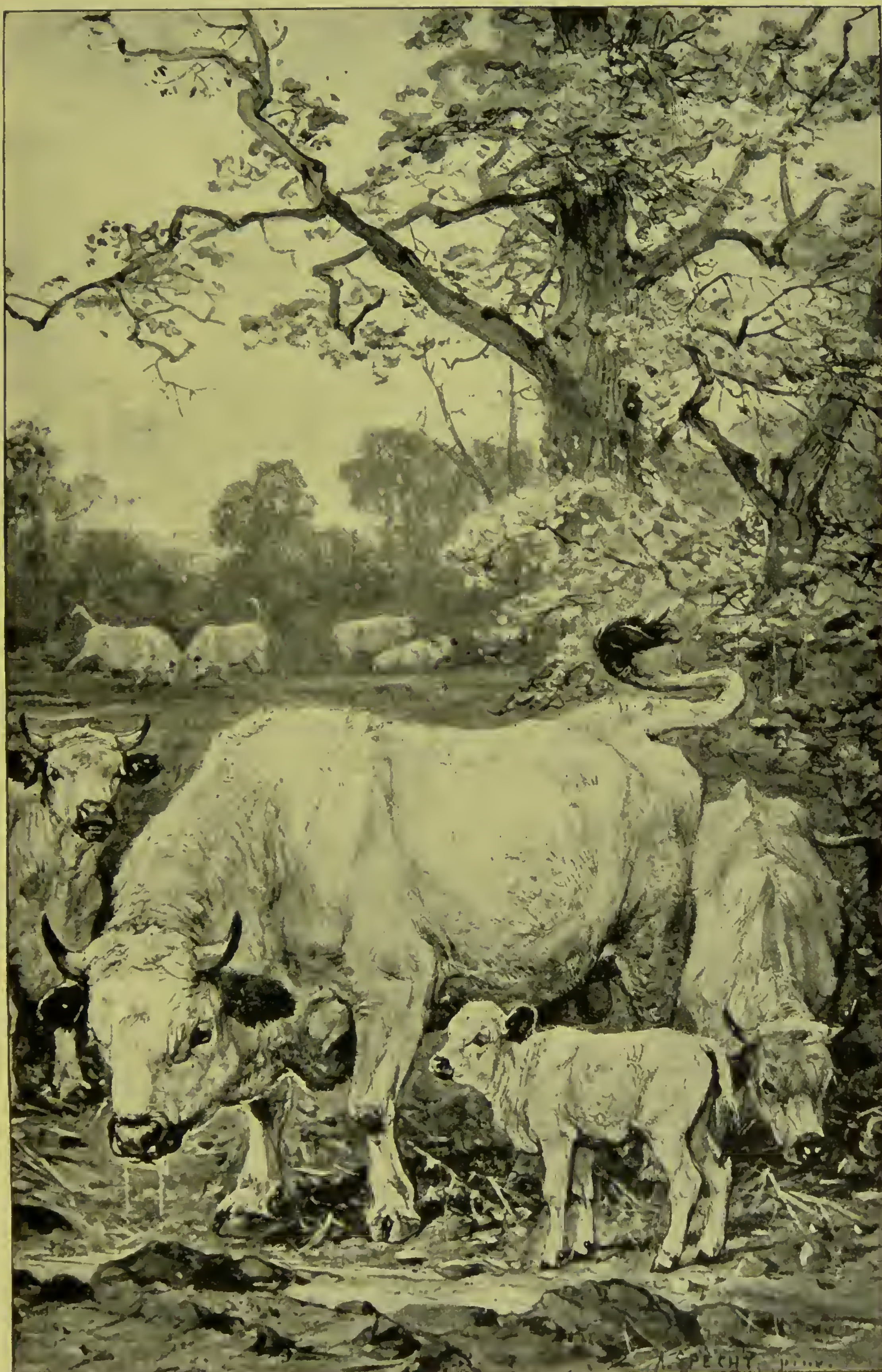
buffelus), ranging from India and Ceylon to South Europe. It is a descendant of the wild Indian Buffalo (*Bubalus arni*).

It is scarcely necessary to remark that oxen, besides serving as an important source of food, are useful in many other ways. In South Africa, for instance, it would be difficult to exaggerate their value for purposes of transport, while in many countries they are used to draw the plough, as, *e.g.*, in Hungary (fig. 1161). Tallow, hoofs, horns, and hides are the most valuable products of the carcase, meat alone excepted. This may be illustrated by the fact that raw hides were imported into this country in 1902 to the value of £2,441,000. It may be added that in June, 1903, the total number of cattle in the United Kingdom amounted to 11,408,560, *i.e.* about 148 head per thousand acres.

The Sheep (Ovis aries).—Wild Sheep of various species are characteristic of the Northern Hemisphere, and different origins must be sought for the domesticated forms of different areas. Regarding the breeds with which we are familiar in this country there is much difference of opinion, but it is probable that some of them represent a mixture of several different strains. We know that during the Newer Stone Age (Neolithic period) the sheep existed in a tame condition, though it would appear to have been domesticated subsequent to the ox, and the bones that have been found, *e.g.* in connection with some of the Swiss lake-dwellings, indicate a slender and rather goat-like creature. But here, as in the case of our other familiar farm mammals, the question of origin is complicated by the consideration that the invading Neolithic tribes, who drove out the rude hunters and fishermen of the Older Stone Age (Palæolithic period), probably brought domesticated animals with them. If we knew with certainty whence these immigrants came, the problem would be rather less complex, but our knowledge on this point is unfortunately very incomplete. Grave doubt has been cast upon the picturesque view that Central Asia is the "cradle" of the Aryan race, and that the mixed populations of Europe mainly result from successive "waves" of immigration which have radiated from this centre. It is more likely that Neolithic man was of North African stock, and invaded Europe from the south. He certainly at one time inhabited Corsica, Sardinia, Sicily, and South Italy. In view of the possible correctness of the view indicated, it may be well to remember that a wild species of

WILD CATTLE OF CHILLINGHAM

The origin of our domestic breeds of cattle is a question regarding which many conjectures have been made, though the matter is still involved in considerable doubt. They are possibly in part descended from the gigantic prehistoric Wild Ox (*Bos primigenius*) of Western Europe, which survived into historic times and was probably the form known to the ancient Romans by the name of Urus. In Chillingham Park, Northumberland, and elsewhere, wild white cattle are still preserved, and it is considered by some authorities that these are to be regarded as the dwarfed descendants of the Urus. This view, however, cannot be regarded as definitely established.



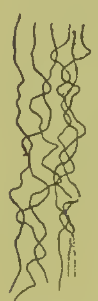
BRITISH WILD CATTLE (BOS PRIMIGENIUS) IN CHILLINGHAM PARK

sheep, *i.e.* the Barbary Sheep (*Ovis tragelaphus*), is now peculiar to North Africa, and another, the Mouflon or Musimon (*O. musimon*, fig. 1163), is limited to Corsica and Sardinia, though it probably once had a wider distribution. One or both these species have possibly contributed a strain towards the formation of our ordinary tame varieties.

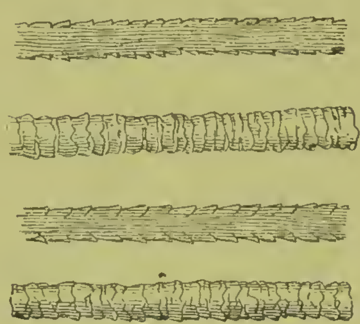

Fig. 1163.—The Mouflon (*Ovis musimon*)

As dwellers among mountains and rocky uplands, Sheep occupy a different place in nature from Oxen, and being close browsers are able to live comfortably on herbage quite unsuitable for horned stock, as may be seen in the barren "sheep-walks" of Central Wales. The practical importance of this is sufficiently obvious. In assessing the value of these animals from the economic stand-point, we have to reckon not only with meat and, to a less extent, milk, but also with wool, a material that has played an important part in the history of textile industries. In the colder parts of the globe clothing of some sort ranks as a necessity, which the prehistoric hunter supplied by roughly stitching together the skins of various animals, sinews being used as thread. This kind of clothing is still in vogue among many savage or half-civilized races. Lord Avebury thus speaks (in *Prehistoric Times*) of the Esquimaux in this connection:—"The clothes of the Esquimaux are made from the skins of reindeer, seals, and birds, sewn together with sinews. For needles they

use bones either of birds or fishes; yet with these simple instruments they sew very strongly and well. The outer dress of the men resembles a short greatcoat, with a hood that can be pulled over the head if necessary, and which serves as a substitute for a hat or cap. Their under-garments or shirts are made of bird-skins with the feathers inwards; or of skins with the hair inside; sometimes, however, they wear in addition another shirt made of seal's entrails. Their breeches are either of seal-skin or reindeer-skin, and their stockings of skins from very young animals. The boots are of smooth black dressed seal's leather, and sometimes when at sea they wear a great overcoat of the same material. The dress of the women does not differ much from that of the men."



Fibres of Wool



Fibres of Wool as seen under Microscope

Fig. 1164

For temperate climates skins are far from being a convenient form of clothing, and among the prehistoric races of Europe were gradually replaced by woven fabrics. Coarse materials of the sort made from flax or straw fibres, have been discovered in connection with some of the Swiss lake-dwellings referred to the Stone Age, at a time when tame sheep were few in number. But when this animal became an important domesticated form the possibility of replacing flax, &c., by wool came to be realized. And among the remains of the Bronze Age in Jutland various woollen garments have been found.

The coat of a Mammal typically consists of outer hair, more or less harsh in texture, and soft under-fur, the two being present in different proportions in different cases. The "wool" of Sheep is a specialized kind of under-fur, the individual hairs of which are wavy or crimped, and covered with well-marked overlapping scales, that promote felting together (fig. 1164). Considerable variations exist as to length, fineness, &c., and the fleeces of certain existing breeds are noted for their valuable qualities. In South-west Asia there is a remarkable variety of the domestic form, known as the Flat-Tailed Sheep, in which the tail is enormously large and fat, weighing as much as 40 or 50 lbs. A miniature sledge or cart is often attached to animals of the kind,

for the more convenient carriage of this monstrous appendage. The nomad races of the steppes of Asia possess vast flocks of a related variety, in which, however, the flat tail is very short, and the fat is concentrated on the sides of the rump. The colour of the breed is black, white, or a mixture of the two, and the familiar "Persian lamb" and "astrachan" of commerce are the product of young animals of this breed. The Merino Sheep, originally confined to Spain but now widely distributed, is noted for the length and fineness of its wool.

Fig. 1165.—Angora Goats

The economic importance of wool may be illustrated by the statement that in 1902 our import (worth £20,236,000) amounted to 678 million pounds, and the home production to 136 million pounds. Of these amounts 320 million pounds were exported, while the remainder, *i.e.* 494 million pounds, was worked up for home use.

The Goat (Capra hircus).—Although this animal does not rank so high as the sheep from the economic stand-point, it possesses considerable value as a source of meat, dairy products, and clothing. We know that it was domesticated by the Swiss lake-dwellers during the Stone Age in rather greater numbers than the sheep. In the same remote period goats, as well as sheep and oxen, were among the tame animals possessed by prehistoric man in Britain.

The most important wild animal from which the domesticated Goat of Europe has taken origin is probably the Grecian Ibex or Bezoar Goat (*Capra ægagrus*), which at the present time ranges from Crete to North-west India. But there is very likely an admixture of one or more other strains.

So far as civilized nations are concerned, the most important products obtained from the Goat are kid-skin, for glove-making, and "mohair", which is the long silky over-hair of certain Asiatic breeds. The chief source of the latter is the well-known Angora Goat, native to Asia Minor, and distinguished by the beauty of its long white silky coat (fig. 1165). The Kashmir Goat, which also ranges into Tibet and the Asiatic steppes, possesses an undercoat of fine soft wool, and it is this which is made into the familiar Kashmir shawls. Large herds of the steppe variety are among the most valuable property of the nomad tribes, not only on account of their skins and wool, but also as a source of meat, milk, butter, and cheese.

The Camel (Camelus).—Being eminently adapted to desert conditions the Camel has been a most valuable domestic animal in Asia and Africa from very remote times. There are two species, the one-humped Arabian Camel (*Camelus dromedarius*), which is the familiar kind introduced by the Arabs into Africa, and the two-humped Bactrian Camel (*C. Bactrianus*, fig. 1166) of Central Asia. It is doubtful whether either species exists in the wild condition. Both are represented on the Assyrian monuments. The most important use of Camels is to serve as beasts of burden, a large animal being able to carry 1000 pounds weight or more for a distance of 30 to 35 miles a day. Several breeds exist, and a distinction may be drawn between baggage-camels and racing-camels or dromedaries. The latter are capable of maintaining a pace of from 8 to 10 miles an hour for a considerable part of the day. There are also various crosses between Arabian and Bactrian camels.

Camels are most valuable as beasts of burden, both in peace and war, but they are also an important source of meat and milk, while the thick wool of the Bactrian species is greatly esteemed for textile purposes. The Arabian Camel is by no means limited to Africa and Arabia, for it ranges also from Syria to North-west India, and has been introduced into Italy, Spain, the Canary Islands, North America, and Australia. It is probably of Indian stock.

THE LLAMA (LAMA LAMA) AND ALPACA (L. PACOS).—We know from geological evidence that creatures of the camel kind first came into existence in North America. Thence some of them migrated into the Old World, passing over a land area that once existed in the North Atlantic (or *viâ* land uniting Alaska and

Fig. 1166.—Kirghiz with Bactrian Camels (*Camelus Bactrianus*).

Asia), while others made their way into South America. From the former Camels took origin, and from the latter the cameline forms of South America, with which we are now concerned. All animals of the sort having become extinct in the intervening area, and submergence of the connecting land having isolated the Old World from the New, the group has come to be distributed in a discontinuous manner.

The domesticated camelines of South America are the Llama

and Alpaca, both probably derived from the wild Guanaco (*Lama guanacus*), which now ranges from the mountain regions of Ecuador and Peru to Tierra del Fuego.

The Llama (*Lama lama*), an animal much smaller than the camel, has been an important beast of burden in Peru and Bolivia from ancient times, though now largely replaced by horses, mules, and oxen. Its flesh and wool are also of value. At the time of the Spanish Conquest it is said that some 300,000 llamas were employed in transporting silver from the famous mines of Potosi.

Fig. 1167.—Alpacas (*Lama pacos*)

The Alpaca (*L. pacos*, fig. 1167) is somewhat bigger than a large goat, and is bred for the sake of its flesh, and more especially on account of the fine qualities of its fleece, which is distinguished for its softness and elasticity. The fine straight hairs average from 7 to 9 inches in length, and are strong without being coarse, differing in this respect from wool of other kinds.

The Pig (Sus scrofa).—While oxen, sheep, and goats are well adapted to the needs of pastoral nomad races, it is quite otherwise with swine, which are notoriously difficult to drive from place to place. Their domestication is, in fact, one mark that their owners have abandoned a wandering life, and entered upon the agricultural stage of civilization, which is a distinct advance upon the pastoral one. We should expect therefore that the prehistoric

THE LLAMA (*Lama lama*)

The most characteristic domesticated animals of South America are the Llama and its smaller relative the Alpaca (*Lama pacos*), the former being descended from the wild Guanaco (*Lama guanacus*). While Alpacas are kept for the sake of their fleeces, as well as for their flesh, Llamas are chiefly useful as beasts of burden, and are employed for this purpose in the high Andes. They are closely allied to the Camels of the Old World, and therefore belong to the Ruminants.

50

LLAMAS (LAMA LAMA) CARRYING GOODS IN THE ANDES

races of the Old World would tame the ox, the sheep, and the goat before turning their attention to the pig, and the evidence of the lake-dwellings of Switzerland favours such a conclusion, for in that area at any rate swine were not domesticated till the Age of Stone had given way to the Age of Bronze. And positive evidence is also available to show that the Swiss lake-dwellers of the latter period cultivated several kinds of grain, and were, in fact, agriculturists of a primitive kind.

Ordinary European Swine are probably not an unmixed race, but the predominant strain in them is derived from the Wild Boar (*Sus scrofa*), which at the present time is widely distributed through Europe, North Africa, West Asia, and Central Asia. It inhabited Britain down to the end of the sixteenth century. The Wild Boar of India, Ceylon, and Further India is probably a variety of the same species. The domesticated pigs of China and Japan would appear to be of entirely different origin.

The uses of the Pig are manifold, and too well known to require detailed notice. As Simmonds says (in *Animal Products*): "It is the animal in which there is the least waste between the dead and living weight, nearly all the carcase being utilized. The blood, the skin, the head, and most of the entrails, which are useless in other animals, serving as food." Leather, bristles, and lard (employed for a great variety of purposes) are the most valuable of the remaining products. In 1902 this country imported about 328,600 tons of bacon and ham, the value of which was £17,285,867. And it was estimated that in June, 1903, the number of swine in the United Kingdom amounted to 4,085,764.

The Horse (Equus caballus).—Wild Horses were among the animals hunted by prehistoric man in Europe during the Stone Age, as we know from contemporary drawings that have come down to us from the times (Newer Palæolithic period) which immediately preceded the final (or Neolithic) epoch of that age, when the implements and weapons of stone were either neatly chipped or carefully polished. It is remarkable that the men of the Newer Palæolithic period were possessed of considerable artistic power, as is now the case with the Esquimaux, their possible descendants, and they whiled away part of their leisure time by scratching spirited outlines of various wild animals on pieces of bone, ivory, or antler. One such drawing representing two hog-maned horses is depicted in fig. 1168. It would appear,

however, that the Horse was not domesticated in Europe until the Bronze Age, or at least not to any large extent.

At the present time there do not appear to be any truly wild horses of the same species as our domesticated breeds, and the so-called "wild horses" of South America, for example, are simply feral, *i.e.* the descendants of tame animals which have escaped from captivity. There is, however, a small kind of horse (*Equus Przewalskii*, fig. 1169) native to the desert regions of Central Asia, which possibly approaches in some respects to the ancestral

Fig. 1168.—Prehistoric Hog-Maned Horses (from Isaac Taylor's *The Origin of the Aryans*, by the courtesy of Mr. Walter Scott)

Fig. 1169.—Przewalsky's Horse (*Equus Przewalskii*)

stock. The mane is not well developed, and the tail resembles that of a donkey. The greatly specialized limbs of horses and their allies have undoubtedly been evolved as an adaptation to swift progression on plains of desert or steppe nature (see vol. iii.

p. 140), and it is probable that in colour and markings the ancestral forms harmonized more or less with their surroundings. Darwin long ago suggested that the bars and stripes so often present on various parts of the bodies of domesticated horses may be a case of atavism, *i.e.* "reversion" or "throw back" to ancestral characters. Cossar Ewart has greatly elaborated and adduced fresh evidence in support of this view; in his opinion primeval horses were clothed in "striped khaki", with short forelock and hog-mane (as in

Fig. 1170.—Head of "Matopo", Prof. Cossar Ewart's Zebra (*Equus Burchelli*), and of a Norwegian Pony

the prehistoric drawings). Fig. 1170, which Professor Ewart has kindly permitted me to borrow from his book (*The Penycuik Experiments*), shows how the head-stripes possessed by a particular Norwegian pony compare with those on the head of a Zebra, an animal which might almost be described as a striped and hog-maned latter-day horse. The following quotation is taken from the book just mentioned:—"We can only guess as to the colour of the remote ancestor of the horse, but nearly all who have made a special study of the subject have come to the conclusion that the

less remote ancestors were dun-coloured. But it is hardly sufficient to say the ancestors were dun-coloured, for in Norway four shades of dun are recognized, which include nearly every colour from white to black. There are (1) white duns (white and light creams) with white mane and tail; (2) yellow duns with black mane and tail, including creams and light bays; (3) elk duns, frequently approaching in hue bays, chestnuts, and browns; and (4) mouse duns, some of which are nearly black. After a full consideration

Fig. 1171.—Arabian Horse

of the subject, I am inclined to believe the body-colour of the striped ancestral horse of the temperate regions was mainly of a yellowish-brown colour. As the descendants extended their range the ground-colour would change, a sand colour probably prevailing in desert areas, a reddish dun in the vicinity of forests, a mouse dun in the far north, a light tint near the tropics, and in the uplands a gray or ash tint." There is a marked resemblance between Norwegian ponies and certain Indian breeds, in view of which it is interesting to notice that according to the traditions of Scandinavia the horse was introduced into that region from the East by the god Odin. But though the body of evidence is on the whole in favour of the view that Central Asia is the old home of

the domesticated species of horse, it must not be forgotten that equines, like camelines, were originally evolved in North America.

The horse, like many other forms domesticated from ancient times, presents a great variety of breeds, produced by artificial selection, and suitable for widely different purposes. Arabians, Clydesdales, and Shetland ponies or "shelties", may be taken as examples (figs. 1171–1173).

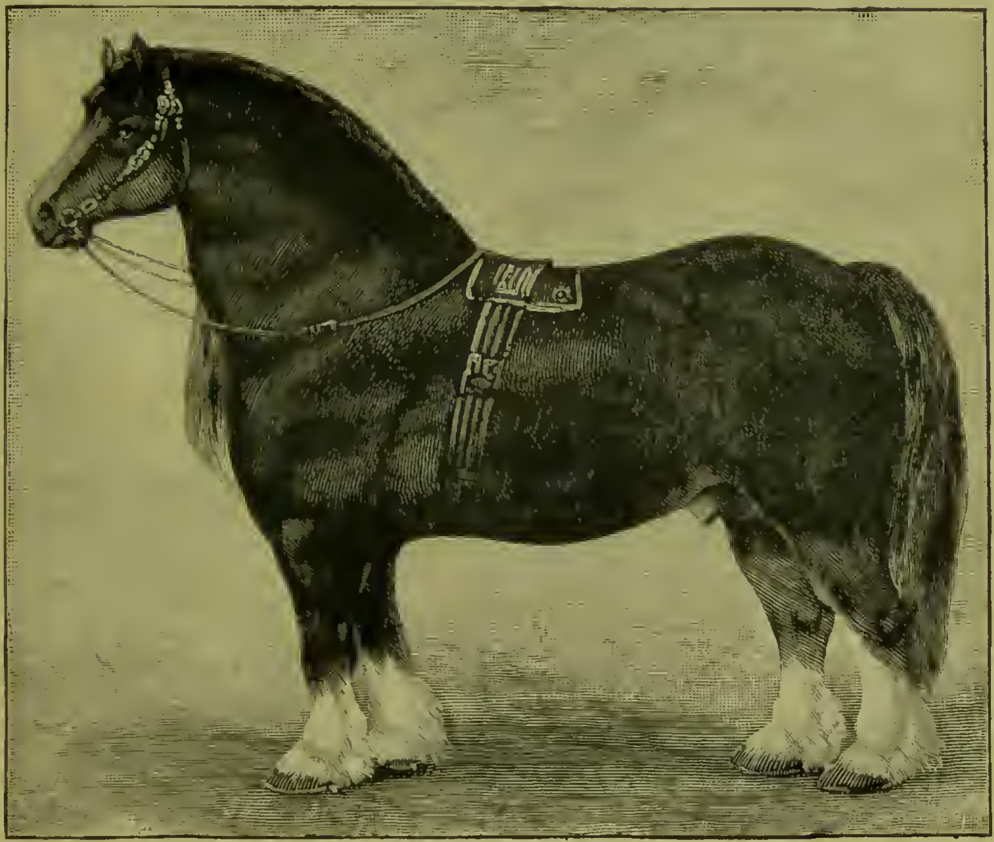


Fig. 1172.—A Clydesdale

It is unnecessary to dwell upon the important services rendered by the horse to man, alike during peace and in times of war, as a draught animal and for riding purposes. And among our dumb intimates he ranks second only to the dog. The return of live stock of the United Kingdom for June, 1903, included 2,069,859 horses, a modest total compared to over 16½ millions possessed by the United States, and over 22 millions by Russia.

Horse-flesh is by no means unimportant as an article of food, and probably plays a more prominent part in the dietary of Europe than is commonly suspected. The hide is of considerable value, and horse-hair is put to various uses, though the once familiar

hair-cloth, figuring as an eminently respectable if slippery covering for chairs and sofas, has been replaced by cheaper and more attractive materials.

THE ASS (EQUUS ASINUS).—Many of the purposes served by the horse are discharged with considerable efficiency by his

Fig. 1173.—A Shetland Pony

humbler cousin, a comparatively late-comer to Western and Central Europe, though domesticated from a very remote period by the Egyptians and other races (fig. 1174). It would be a mistake to base our judgment of the species upon the ill-fed and

Fig. 1174.—Egyptian Sculpture

too often cruelly treated donkeys seen in this country, for some of the breeds of South Europe and the East are handsome and even graceful. White asses have long been esteemed, as may be illustrated by an allusion in the Old Testament, "Speak, ye that ride

on white asses, ye that sit in judgment, and walk by the way" (Judges v. 10). The undeserved obloquy from which the modern "moke" suffers is, however, the survival of a very ancient prejudice. Possibly the original source of derision is to be looked for in the shockingly inharmonious voice of this unfortunate creature. The views of the ancient Egyptians on the subject are thus summarized by Houghton (in *Natural History of the Ancients*):—"The ass was sacred to Typho, 'the Evil Being'. According to Plutarch, the Coptites had the custom of throwing an ass down a precipice; and the inhabitants of Busiris and Lycopolis carried their detestation of it so far as never to make use of trumpets, fancying that their sound is similar to the braying of an ass. Even the colour of the unfortunate ass—which, in Egypt, as in ancient Palestine, was of a redder tint than is usual with the domestic ass of England—was looked upon as indicative of the Evil Being, and any unhappy man who was of a ruddy complexion, or had decidedly red hair, was thought to be related to the Evil Being (Typho)."

Several species of wild donkey are native to Asia and Africa. One of the latter, the Nubian Ass (*Equus Africanus* or *tæniopus*), is probably ancestral to the domesticated form. The original stock most likely resembled in colour and markings that from which horses have sprung.

It may conveniently be noted here that the the striped Tiger-Horses or Zebras, of which Africa possesses three indigenous species, are not the wild and intractable creatures once supposed, but are susceptible to domestication. Nor do the zebras of the "fly" districts succumb to the bites of the tsetse-fly, an insect that makes considerable tracts in tropical Africa impossible for horses.

Mules and Zebra-Mules.—It is a familiar fact that ordinary mules are crosses or hybrids between horse and ass. On account of their strength, endurance, and sure-footedness they are invaluable beasts of burden in mountainous countries, and play a more important part both in peace and war than is commonly realized in England, where there is considerable prejudice against them. Probably Spain has made more use of them than any other nation, especially in the New World. The importance of the mule in war so far as the British Empire is concerned has been abundantly demonstrated in our African and Indian campaigns, and its value in peace is also considerable.

Unfortunately mules are often vicious, stubborn, and difficult to manage, and probably on this account have not so far been used so much as might be desired in the development of the resources of the mountainous parts of the empire. A partial solution to the problem may perhaps be found in the employment of zebra-mules, *i.e.* crosses between horse and zebra (fig. 1175), which are much more docile than ordinary mules. This step has been advocated by Captain Lugard, Major von Wissmann, and Professor

Fig. 1175.—"Sir John", one of Prof. Cossar Ewart's Zebra Hybrids (sire "Matopo", see fig. 1170; dam "Tundra", an Iceland pony)

Cossar Ewart, the last of whom makes the following remarks on the subject (in *The Penycuik Experiments*):—"I have already referred to the views of Captain Lugard. He writes: 'Some years ago I advocated experiments on taming the zebra, and I especially suggested that an attempt should be made to obtain zebra-mules by horse or donkey mares. Such mules, I believe, would be found excessively hardy, and impervious to the 'fly' and to climatic diseases. . . . I would even go further, and say that their export might prove one of the sources of revenue and wealth in the future; for, as everyone knows, the paucity of mules both for mountain batteries and for transport purposes has long been one of the gravest difficulties in our otherwise

almost perfect Indian Army Corps.' Since this was written much information has been gained as to the dreaded tsetse-fly, but apparently there is extremely little chance of horses being made immune, *i.e.* so treated by inoculation or otherwise that they will be able to survive if once infected by the peculiar minute organism so intimately associated with the all too fatal disease. Further, owing to the destruction of cattle by the rinderpest, the transport difficulties have been increased in Africa, while the frontier wars have increased the demand for mules in India. On the other hand, it has been proved that it is a comparatively simple matter to cross various breeds of mares with a Burchell zebra, and if experts are to be trusted, the hybrids (zebra-mules, as some call them) promise to be as useful and hardy as they are shapely and attractive. The preliminary difficulties having been overcome, it remains for those in authority to ascertain of what special use, if any, zebra hybrids may be in various parts of the Empire, but more especially in Africa and India." Prof. Ewart, in a recent letter (March, 1904), has kindly supplied me with further information.—" Some of the hybrids are constantly being driven in Hamburg. Eight of those I bred are going to the St. Louis Exposition. Apparently a hybrid withstands the tsetse poison better than a zebra which has not been reared in the 'fly' country. Some of the hybrids out of Iceland (inbred) ponies are extremely tractable, and can be used for carrying children."

THE ELEPHANT.—Although both African and Indian Elephants can be tamed, it is only the latter species that has been of very great service to man as a domesticated animal. Its considerable intelligence and enormous strength make it useful as a beast of burden and for lifting heavy weights (fig. 1176). For such purposes, and also in war, it has been employed in the East from very remote times. But its nervous temperament and uncertain temper constitute serious drawbacks, especially in the case of the males. Some of the characteristics of this animal are thus described by Sir Samuel Baker (in *Wild Beasts and their Ways*):—" Although I may be an exception in the non-admiration of the elephant's sagacity to the degree in which it is usually accepted, there is no one who more admires or is so foolishly fond of elephants. . . . There is, however, a peculiar contradiction in the character of elephants that tends to increase

the interest in the animal. If they were all the same, there would be a monotony; but this is never the case, either among animals or human beings, although they may belong to one family. The elephant, on the other hand, stands so entirely apart from all other animals, and its performances appear so extraordinary owing to the enormous effect which its great strength produces instantaneously, that its peculiarities interest mankind more than any smaller animal. Yet, when we consider the actual aptitude for learning, or the natural habits of the creature, we are obliged to confess that in proportion to its size the elephant is a mere fool in comparison with the intelligence of many insects. . . . It actually does nothing remarkable, unless specially instructed; but it is this inertia that renders it so valuable to man. If the elephant were to be continually exerting its natural intelligence, and volunteering all manner of gigantic performances in the hope that they would be appreciated by its rider, it would be unbearable; the value of the animal consists in its capacity to learn, and in its passive demeanour until directed by the mahout's commands." The same writer advocates, in the following words, the domestication of the African species:—"It is much to be regretted that no system has been organized in Africa for capturing and training the wild elephants, instead of harrying them to destruction. In a country where beasts of burden are unknown, as in equatorial Africa, it seems incredible that the power and the intelligence of the elephant have been completely ignored. . . . When we consider the peculiar power that an elephant possesses for swimming long distances, and for supporting long marches under an enormous weight, we are tempted to condemn the apathy even of European settlers in Africa, who have hitherto ignored the capabilities of this useful creature. The chief difficulty of African commerce is the lack of transport. The elephant is admirably adapted by his natural habits for travelling through a wild country devoid of roads. He can wade through unbridged streams, or swim the deepest rivers (without a load), and he is equally at home either on land or water. His carrying power for continued service would be from 12 to 14 cwts.; thus a single elephant would convey about 1300 lbs. of ivory in addition to the weight of the pad. The value of one load would be about £500. At the present moment such an amount of ivory would employ twenty-six carriers; but

as these are generally slaves which can be sold at the termination of the journey, they might be more profitable than the legitimate transport by an elephant." Sir Harry Johnston, while in favour of experiments in this matter, thus expresses his forebodings as to the result:—"The question of its domestication and usefulness to man is a very doubtful one. It is relatively easy to obtain young African elephants, and to tame them in a few days or a few weeks. It is also easy to train them to bear burdens on their backs or to perform other simple tasks, but it cannot be

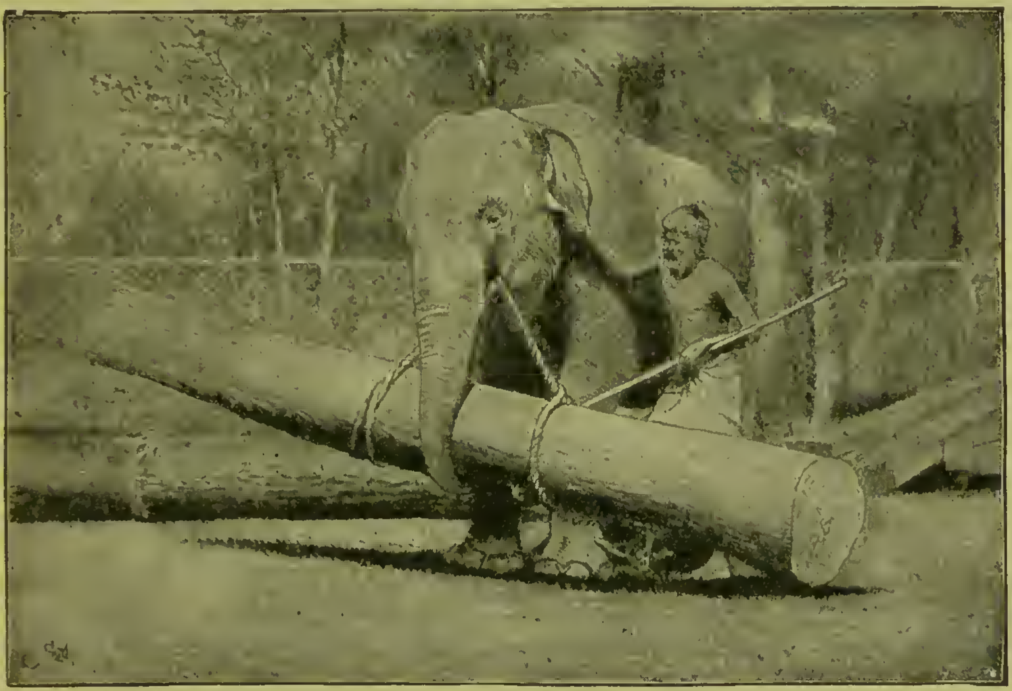


Fig. 1176.—An Indian Elephant (*Elephas Indicus*) lifting Timber

said as they grow up that they evince the same docility that is characteristic of the Indian elephant, while after the males have reached maturity they are positively dangerous. Something might be done with the adult female African elephant." (*Nature*, 1904.)

THE RABBIT (LEPUS CUNICULUS) AND HARE (L. TIMIDUS).— The various breeds of Rabbit which are domesticated in Europe are all descended from the common wild form, which was originally restricted to the countries bordering the Western Mediterranean, and the islands of the same region. Some of the races, especially Chinchillas and Angoras, are valued on account of their fur, the flesh being also utilized (fig. 1177). In this country they are chiefly kept as pets, and for show purposes.

The Rabbit has long played a minor part in the civilization of various peoples, regarding which Darwin gives the following information (in *Animals and Plants under Domestication*):—"The tame rabbit has been domesticated from an ancient period. Confucius ranges rabbits among animals worthy to be sacrificed to the gods, and, as he prescribes their multiplication, they were probably at this early period domesticated in China. They are mentioned by several of the classical writers. In 1631 Gervaise Markham writes: 'You shall not, as in other cattell, looke to their shape, but to their richnesse, onely elect your buckes, the largest and goodliest conies you can get; and for the richnesse of the skin, that is accounted the richest which has the equallest mixture of blacke and white hair together, yet the blacke rather shadowing the white; the furre should be thicke, deepe, smooth, and shining; . . . they are of body much fatter and larger, and, when another skin is worth two or three pence, they are worth two shillings'. From this full description we see that silver-gray rabbits existed in England at this period; and, what is far more important, we see that the breeding or selection of rabbits was then carefully attended to."

Fig. 1177.—Angora Rabbit

Although the Hare cannot now be called a domesticated animal, it was so in ancient Rome, as it happened to be one of the numerous animals relished by the epicure, its shoulder in particular being esteemed a dainty. The animals were kept in a hare-preserve or leporarium, which was a large enclosed park. They were sufficiently tame to come and be fed in winter, a horn being blown as a signal to them. At first, it would seem, intended for hares only, the leporaria were at a later date tenanted by rabbits as well, these having been introduced from Spain.

The Fat Dormouse or Loir (Myoxus glis, fig. 1178).—This was another animal that appealed to the palate of the Roman epicure. Houghton gives the following account of the way in which it was treated (in *Natural History of the Ancients*):—"Dormice (*glires*) were very highly esteemed as food by the old Romans. Small yards were walled around, in which were planted

oak-trees to supply the animals with acorns. These preserves were called *gliraria*; holes were dug in the inside of the yard for the dormice to breed in; a little water was supplied to them, but dry soil was necessary. They were fattened in large jars (*doliis*), and were plentifully supplied with acorns, chestnuts, and walnuts. In these dark places they soon got fat. . . . Dormice

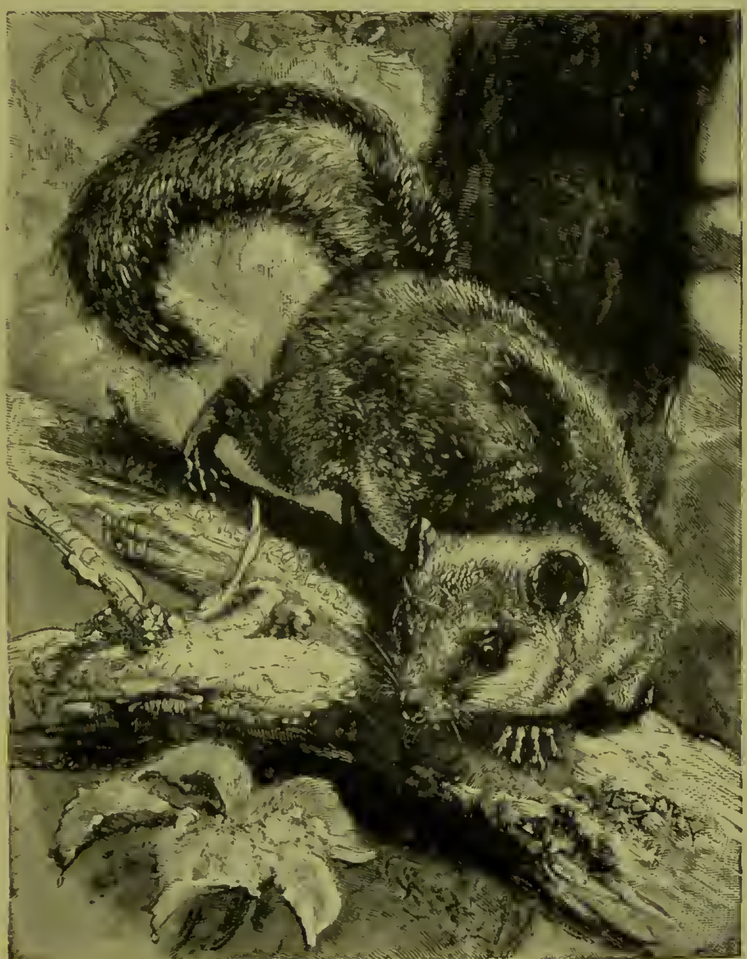


Fig. 1178.—The Fat Dormouse or Loir (*Myoxus glis*)

were considered articles of such luxury that one of the consuls, M. Scaurus, prohibited them by a censor's edict, and, as Pliny says, 'they were banished from our tables'. Notwithstanding this edict, however, a *glirarium* appears to have been an ordinary adjunct of a Roman gentleman's villa. . . . I believe the fat dormouse is still eaten in some parts of Italy, but how far the flavour depended on the inherent good quality of the creature's flesh, or on the mode in which it was cooked, I am unable to say."

BIRD (AVES) AS DOMESTICATED ANIMALS

THE FOWL (GALLUS DOMESTICUS). — The very numerous breeds of domesticated fowls, some of which differ greatly from one another in appearance, are generally held to be all descendants of the Red Jungle Fowl (*Gallus bankiva* or *ferrugineus*), which at the present time ranges from North India through South-east Asia and part of the East Indies to the Philippines. Among the domesticated races Game-Fowls most nearly resemble the original type (fig. 1179).

Fowls are valuable not only because they and their eggs are important articles of diet, but also on account of their feathers, which are put to various uses. Poultry-farming is now rightly regarded as one of those minor agricultural industries upon which the prosperity of the small farmer and the peasant largely depends. A good instance is afforded by the Irish egg-industry. Not many years ago the product was notorious in England on account of the uncertain age of the eggs which were put upon the market; these being only in great demand for election purposes. And the industry, such as it was, benefited the Irish farmer but little, being exploited by persons having no stake in the development of the agriculture of the country. But now, thanks to the co-operative policy of Sir Horace Plunkett, which has been in every way of enormous benefit to Ireland, the Irish eggs, sorted, cleansed, and properly packed, can be sold in the London market within three days after being laid; and the very considerable profits directly benefit the farmers and peasantry. A similar story regarding Irish butter might have been told when the importance of horned stock was emphasized in an earlier paragraph.

Fowls do not appear to have formed part of the live stock of the prehistoric races of Europe, but that they have been tamed for a long period of time will be gathered from the following quotation (Newton—*A Dictionary of Birds*):—"Several circumstances seem to render it likely that Fowls were first domesticated in Burma or the countries adjacent thereto, and it is the tradition of the Chinese that they received their poultry from the West about the year 1400 B.C. By the Institutes of Manu, the date of which is variously assigned from 1200 to 800 B.C., the tame fowl is forbidden, though the wild is allowed

to be eaten—showing that its domestication was accomplished [in India] when they were written. The bird is not mentioned in the Old Testament, nor by Homer, . . . nor is it figured on ancient Egyptian monuments. Pindar mentions it, and Aristophanes calls it the Persian bird, thus indicating it to have been introduced to Greece through Persia, and it is figured on Baby-

Fig. 1179.—Game-Fowls

lonian cylinders between the sixth and seventh centuries B.C. It is sculptured on the Lycian marbles in the British Museum (*circa* 600 B.C.), and Blyth remarks (*Ibis*, 1867) that it is there represented with the appearance of a true Jungle Fowl, for none of the wild *galli* have the upright bearing of the tame breeds, but carry their tail in a drooping position."

The Duck (Anas boschas).—Ducks are of less importance than Fowls, but their uses are much the same. There is little if any doubt that the ordinary breeds of domesticated Duck

are descended from the Mallard or Wild Duck (*Anas boschas*), which has a wide distribution in the Northern Hemisphere. This bird seems to have been tamed at a later date than the Fowl, but it was apparently kept in a state of semi-domestication by the Greeks so long ago as the time of Aristophanes (448(?)-388 B.C.). From them the Romans appear to have learnt its virtues, but we gather from Varro (116–27 B.C.) that in his time the taming process was not complete, for he states that duck-enclosures should be covered with nets, to prevent the escape of their inmates, as well as to exclude predaceous animals.

Fig. 1180.—Gray Lag Geese (*Anser cinereus*)

Other species of duck are also domesticated in Europe, especially the Musk or "Muscovy" Duck (*Cairina moschata*), native to South America.

The Goose (Anser domesticus).—Geese have been domesticated from very remote times, on which point Darwin remarks (in *Animals and Plants under Domestication*):—"That geese were anciently domesticated we know from certain verses in Homer; and from these birds having been kept (388 B.C.) in the capitol at Rome as sacred to Juno, which sacredness implies great antiquity". It is generally held that the tame European breeds are descended from the Gray Lag Goose (*Anser cinereus*, fig. 1180), native to Britain and most countries of the Continent, and ranging east to China. There are but few domesticated varieties, and these resemble one another and the parent stock more than might be expected; there having been far less variation than, *e.g.* in the case of Fowls. The most obvious difference between a tame and a wild bird consists in the lighter or even perfectly white plumage of the former.

The soft under-feathers of geese are largely used for stuffing pillows and beds, being of greater value in this connection than

those of other domesticated birds. And before steel pens came into general use the large feathers from the wing were in great demand for the making of quill-pens, which even now have many admirers.

THE TURKEY (MELEAGRIS GALLOPAVO).—A native of the southern part of North America, this bird was first described in 1527, and is known to have been domesticated in Europe by 1530, having very likely been introduced early in the century. That it soon found favour in this country is evident from the following facts quoted by Newton (in *A Dictionary of Birds*):—

Fig. 1181.—Guinea-Fowls (*Numida meleagris*)

"The earliest documentary evidence of its existence in England is a 'constitution' set forth by Cranmer in 1541. . . . This names 'Turkeycocke' as one of 'the greater fowles' of which an ecclesiastic was to have 'but one in a dishe'. . . . Moreover, the comparatively low price of the two Turkeys and four Turkey-chicks served at a feast of the serjeants-at-law in 1555 (Dugdale, *Origines*) points to their having become by that time abundant, and, indeed, by 1573 Tusser bears witness to the part they had already begun to play in 'Christmas husbandlie fare'."

THE GUINEA-FOWL (NUMIDA MELEAGRIS, fig. 1181).—This form is native to West Africa, and appears to have been domesticated at two different periods, *i.e.* in the times of the ancient Romans, and during the sixteenth century.

Under the term "poultry" may be included fowls, ducks,

geese, turkeys, and guinea-fowl, and the importance of these (especially the first) to agriculture in this country may be seen from the following statistics:—The value of the poultry and eggs consumed in the United Kingdom during 1902 amounted to £16,408,994, including foreign produce worth £7,358,934, Irish produce worth £2,300,000, and produce of Great Britain worth £6,750,000.

The Pigeon (Columba livia).—The wild Blue Rock-Pigeon (*Columba livia*), the races of which have at the present day a

Fig. 1182.—Ostriches (*Struthio camelus*) on a South African Farm

very wide range through Europe, Asia, and North Africa, is believed to be the original stock from which the very numerous domesticated breeds are descended. The ancient Egyptians would seem to have tamed it over 5000 years ago, and it was valued by them not only as a source of food, but also as a means of communication. Its military importance in the latter connections has been abundantly demonstrated in modern times, and it seems destined to play a leading part in the campaigns of the future.

As we shall see in the sequel the theoretical importance of pigeons is very great, for they throw considerable light upon

the question of evolution. The various breeds were studied with the utmost thoroughness by Darwin, and more recent observations show that the subject is by no means exhausted, and that these birds are most desirable subjects for experiment when heredity problems have to be considered.

THE AFRICAN OSTRICH (STRUTHIO CAMELUS).—Although ostriches have been domesticated or semi-domesticated by some of the native tribes of Africa from remote times, the "ostrich farms" of the south are of comparatively recent date (fig. 1182). The inducement to this industry is of course found in the valuable plumage, the white wing-feathers being most esteemed, while those of the tail and also some of the back plumes are also marketable. Birds are in their prime when from three to four years old, and the feathers of the males are of better quality than those of the females. They are plucked or cut off about twice in three years, and are subjected to a number of processes before being fit for use. Ostrich-feathers constitute an important export from Cape Colony, yielding not far short of a million pounds sterling annually. The industry has been introduced with more or less success into several other parts of the world, notably Southern California and Australia.

DOMESTICATED INSECTS (INSECTA)

Under this heading may be placed the Honey-Bee (*Apis mellifica*), the Silk-Worm Moth (*Bombyx mori*, &c.), and the Cochineal Insect (*Coccus cacti*). The industries which these insects render possible are all of ancient date, and the two first of very considerable importance.

THE HONEY-BEE (APIS MELLIFICA).—A liking for sweet things is a wide-spread human weakness, and appears to be of very old standing. Wild bees of different kind are native to many parts of the world, and the honey which some of them store in abundance no doubt soon attracted the attention of primitive peoples, whose most important business in life consisted in the discovery of edibles (compare vol. ii, p. 63). Of a small Brazilian species Bates says (in *The Naturalist on the Amazons*):—"A hive of the Melipona fasciculata, which I saw opened, contained about two quarts of pleasantly-tasted honey. The bees . . . have no sting, but they bite furiously when their

colonies are disturbed." Semon complains of the time wasted in the search for honey by the blacks he employed to hunt out the Spiny Ant-Eater (*Echidna*):—"About a dozen black families had gathered in my camp at that period, but only two or three of them performed any work worth mentioning. The control of their day's labour was very difficult, as we were not able to follow them on their rambles, and to make sure of their really pursuing the track of Echidna and not giving themselves up to sweet idleness or to the search of nests of the stingless Australian bee, of the honey of which they are excessively fond. . . . Many an hour destined for labour did they spend in the pursuit of these bees' nests. Still greater was the loss of time when they discovered a nest of our European honey-bee. Mr. Cole, the doctor in Gayndah, was an eager apiarian, and from his hives European bees, which soon became wild, had spread all over the Middle Burnet. . . . Whenever it happened that my blacks discovered a tree which the immigrated bees had chosen as a dwelling, and the hollow of which they had filled with their sweet stores (often to a height of eleven yards or so above the ground), all the mob would at once assemble to fell the mighty tree, often the work of a day." (*In The Australian Bush.*) Readers will doubtless be able to recall appreciative biblical allusions to the desirable properties of honey.

In the case of the Honey-Bee (*Apis mellifica*), with which we are here more especially concerned, the primitive apprecia-tion of sweets led in very early times to the practice of api-culture. As in so many other things the ancient Egyptians would seem to have led the way, their example being zealously followed by both Greeks and Romans. The littoral of the Eastern Mediterranean was possibly the original home of the species, and, if we include varieties, it now has a wide range in the Old World, and has also been introduced into America, the West Indies, Australia, and New Zealand.

As elsewhere sufficiently indicated, the Honey-Bee represents the final term of specialized social life among its kind, though very possibly some features have been brought about by the influence of long-continued domestication. The leading facts about it are so well known that a brief outline may here suffice. A populous hive will contain a queen, several hundred drones or males, and from 30,000 to 50,000 "workers", *i.e.* imperfectly-

developed females, specialized in various ways so as to be able to perform efficiently the varied duties necessary to the maintenance of the community (fig. 1183). The queen is comparatively large, with slender body, short wings, and a curved sting. Maternity is her sole function, and she is fed and tended with the greatest assiduity by the workers. Except for the nuptial flight, and when migrating with a "swarm" to fresh quarters, she does not leave the hive. Only a single queen is tolerated by workers in the same community, and if one should happen to emerge from a "royal cell" while the reigning queen is still in the hive a duel to the death ensues. If a queen should intrude from outside the result may be similar, or the workers may mob the interloper, though they will not sting her, and death by starvation or suffocation is commonly her fate. A queen is astonishingly fertile, and under favourable circumstances is capable of laying from two thousand to three thousand eggs in a day. Some of these are unfertilized, and develop into drones, but the majority are fertilized, and are usually destined to produce females, though it is not impossible that some of these also may give rise to drones. The life of a queen extends over four or five years.

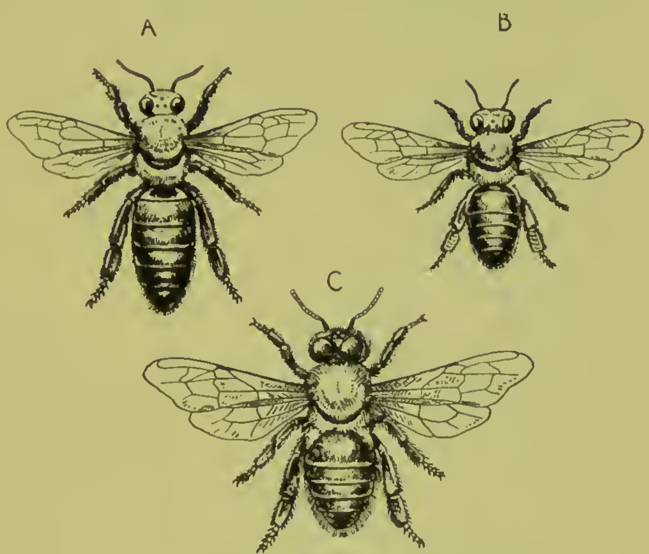


Fig. 1183.—Honey-Bee (*Apis mellifica*), enlarged

A, Queen; B, worker; C, drone.

The stingless drones are smaller and stouter than the queen, and distinguished by the enormous size of their compound eyes. They do absolutely no work, but their presence is patiently submitted to until the end of the summer, because a minute percentage of them are destined to become the fathers of communities. At the approach of autumn, when food is becoming scarce, the drones are mercilessly expelled from the hive, or even, according to some authorities, ruthlessly slaughtered.

The workers are smaller than the drones, and distinguished

by many special characters. One of the most remarkable consists in the possession of a "pollen basket", consisting of a hollow covered by transverse rows of hairs on the inner side of the first joint of the hind-foot (fig. 1184). There are also wax-glands on the under side of the abdomen, by which scales of wax are secreted, this being the chief building material (fig. 1185). The sting is straight, and the mouth-parts better developed than in queen and drones, the proboscis in particular being longer, and well adapted to probe the recesses of flowers in the search for nectar (fig. 1186). These and other specializations are, of course, related to the fact that the workers discharge all the duties of the hive, egg-production alone excepted. A few of them may, however, be fertile under exceptional circumstances, but in that case their eggs invariably hatch out into drones. Workers born late in the season may survive till the following year, but the rest live only for six or eight weeks.

Fig. 1184.—Part of Hind-leg of a Worker Bee, greatly enlarged, to show Pollen-Basket, above which, on right side, may be seen a pincer-like arrangement used for various purposes.

Fig. 1185.—Under Side of a Worker Bee, enlarged, showing plates of wax

The waxen combs made by the workers for storage of food and reception of eggs are suspended vertically, and consist of six-sided cells, of which there is a set on either side of the comb, separated by a thin party-wall (fig. 1187). The long axes of these cells slope slightly outwards and upwards. The smallest of them are for storage and worker-brood, and there is a larger size in which the drones are reared. A comparatively small number of

"royal cells" are constructed at the edges of the combs as circumstances may require. These are somewhat acorn-shaped, with downwardly-directed mouths, and a good deal larger than any of the hexagonal cells. In them the young queens are reared. The workers that produce the wax for comb-construction hang suspended in dense clusters for many hours, until eight little scales of wax have been secreted on the under side of each of them. They then successively visit the highest part of the hive, and

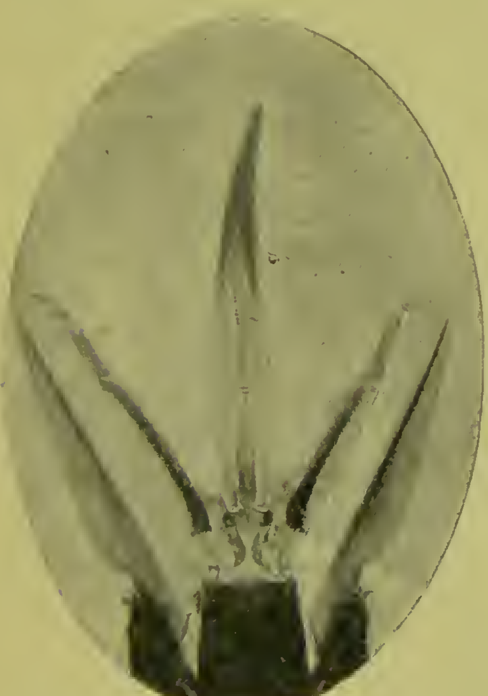


Fig. 1186. Extended Mouth-parts of a Worker Bee, seen from above, with the different regions separated, enlarged. The long "tongue" is seen in the centre, and the second jaws (1st maxillæ) below.

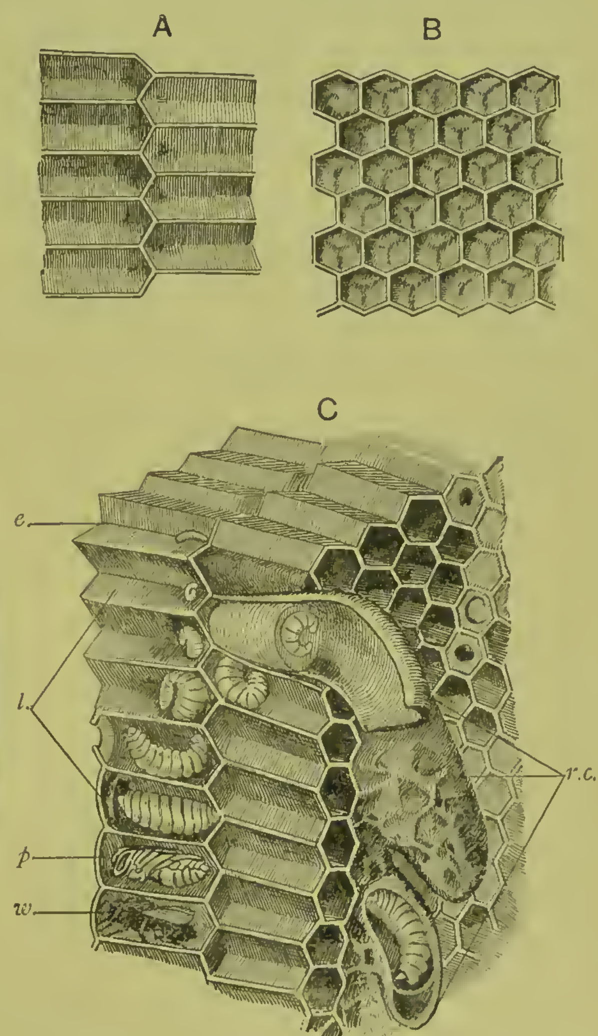


Fig. 1187. Honey-Comb. A, Small cells in section. B, Ditto in surface view. C, Comb with brood, on left development of a worker; egg (*e*), larvæ (*l*), pupa (*p*), imago (*w*); on right are seen royal cells (*r.c.*), the middle one unopened.

work the scales into a lenticular mass. The hind-legs are used for detaching the scales, and the jaws for kneading them. Other workers excavate areas corresponding to the cells, building up the walls of these from the wax scooped out, and as the work proceeds the two sides of the comb are simultaneously operated on by two gangs of labourers. At the same time fresh wax is added as required to the edges of the growing comb.

For filling up the crevices of the hive bees employ "propolis", which consists of resin collected from the buds and bark of trees, especially horse-chestnuts and pines. It is carried to the hive in the same way as pollen.

The limbless grubs which hatch out from the eggs in three days' time are fed and tended by the younger workers, and at first receive a soft substance consisting of honey and pollen that have been swallowed and partly digested by their attendants, with which is mixed a fluid secreted by certain glands of the head. This mixture is commonly known as "royal jelly". Larvæ hatched from unfertilized eggs always become drones, but those emerging from fertilized eggs may become either workers or queens, according to the way in which they are fed. A larva which the workers intend shall become a queen is nourished entirely upon royal jelly, possibly differing in composition from that which the others at first receive. It would appear to be of stimulating nature, for queens develop more quickly than members of the other castes, requiring only 15 days (from the laying of the egg) as against 21 for a worker, and 24 for a drone. The larvæ destined to become workers or drones are quickly "weaned", honey, pollen, and water being substituted for jelly. After being fed for 5 days (or 6 in the case of drones) the larvæ attain their full size, when the workers seal the cells with a mixture of pollen and wax, that permits the diffusion of air. Within its cell the larva spins a silken cocoon, imperfect at the hinder-end in the case of queens, and passes into the motionless pupa stage, from which, later on, the perfect insect emerges, to bite its way out into the hive.

When a hive becomes overcrowded the surplus population, accompanied by the reigning queen, "swarms" out of the hive to seek fresh quarters. This never takes place unless one or more royal cells with inmates are present in the deserted home. When the first young queen emerges from these, her first act is to tear open the remaining royal cells and sting the inmates to death, an operation which is rendered possible by the imperfect nature of the cocoons in which these are enclosed. After a nuptial flight the young queen settles down as the new mother of the community. Sometimes the workers will prevent the first emerged young queen from destroying her sisters, and in that case there is a possibility of the first migration being succeeded by after-

swarms or "casts". Domesticated bees are more given to swarming than wild ones.

Bee-Keeping or Apiculture.—The remarks already made about the importance of poultry-keeping (p. 246), as an adjunct to agriculture, apply here also, though to a less extent. To give a long account of the industry is unnecessary, and readers requiring details will do well to consult Cowan's *British Bee-Keeper's Guide Book*. This writer thus speaks of the paying nature of the industry, and the essentials to success:—"The culture of the honey-bee is now universally admitted to be one of the most profitable of rural pursuits. It has engaged the attention of intelligent persons of all ages; yet it is only comparatively recently—by the introduction of improved movable-comb hives, the honey-extractor, and comb-foundation—that this pursuit has been rendered no longer a matter of chance, but as certain and more remunerative with small outlay than any other rural occupation. Much has been written about the enormous profits to be derived from bee-keeping; and, stimulated by what they have read, persons have purchased a few stocks, and, after keeping them without any attention for some years, have given them up, having failed for want of a knowledge of the first principles of bee-culture. Although anyone may keep bees, it is not everyone who can become a proficient bee-master. Energy and perseverance, together with aptness for investigation, can only ensure real success. While some degree of talent is essential, in this as in every other pursuit, ordinary ability directed to the attainment of a specific end will be more likely to be rewarded by success, than the most extraordinary talent divided among half a dozen different pursuits. The man who is thoroughly conversant with his business, is familiar with its requirements, has mastered its every detail, and who is industrious and energetic, will be likely to succeed; and if, in addition to this, he possesses good executive abilities, his success will be very apt to be above the average."

A few words may be of interest on the three requisites to enlightened apiculture mentioned in the above extract, *i.e.* movable-comb hives, honey-extractors, and comb-foundation. The familiar bell-shaped straw hive or "skep" may be picturesque, but is eminently undesirable. It renders regulation of the bees' labours impossible, necessitates destruction of the combs, and too often means that the industrious insects are choked by the fumes

of burning sulphur as a preliminary to taking their honey. All this is altered in the movable-comb or "frame" hives (fig. 1188). These are square wooden boxes, which open at the top, and contain a number of wooden frames for holding the combs, and easily taken out at pleasure for the purposes of the bee-keeper. They render it easy to regulate the bees, including the swarming, in almost any required way. The reigning queen, for example, can be deposed, and replaced by a more fertile successor, or one of more desirable race.

The honey-extractor is a simple device for rapidly rotating combs so that the honey flies out by centrifugal force, and this is a vast improvement on the old method of crushing and straining. As Cowan very justly remarks:—"When we bear in mind that bees consume about 20 pounds of honey in order to produce one pound of wax, we can realize the advantages of a machine which enables us to give them empty comb, and thus save them the labour of comb-building".

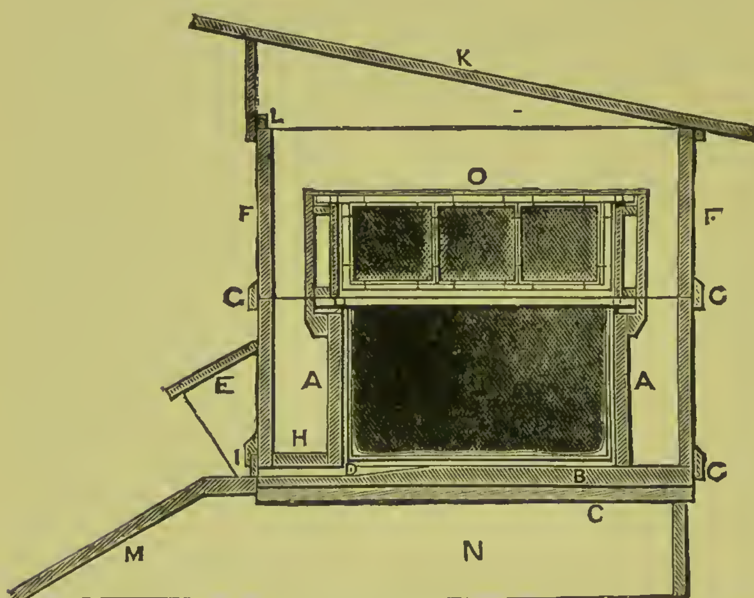


Fig. 1188.—Cowan Hive in Longitudinal Section. A, Body-box; B, floor-board; C, strengthening piece; D, entrance gallery; E, entrance porch; F, outer case; G, protective plinths; H, roof of entrance gallery; I, sliding door at entrance; K, roof; L, roof-catch; M, alighting board; N, stand; O, rack with three sections, below which is seen a frame of comb.

To supply comb-foundation is the next best thing to giving empty combs. This consists of thin plates of wax, which have been passed between suitably-embossed rollers, so that the "foundations" of the cells are laid, and there are also projecting ridges of wax, furnishing enough material for the completion of the cells, save that required to cover them. Foundation is made with either small cells suitable for worker-brood (or storage), or with larger cells adapted for drone-brood. It is possible, by supplying one or other kind as desired, to regulate within certain limits the number of workers and drones produced in the hive.

There unfortunately appear to be no means of ascertaining how far British apiculture is profitable. Honey to the value of £30,349 was imported into this country in 1903.

THE SILK-WORM MOTH (BOMBYX MORI, &c., fig. 1189).—The most important and best-known kind of Silk-Worm Moth is the one (*Bombyx mori*) of which the caterpillar or "silk-worm" feeds upon the leaves of the mulberry-tree. The life-history is sufficiently familiar. From the egg a minute larva hatches out which is full grown in about five weeks, during which time it casts its skin several times. At the end of this period the silk-worm spins a cocoon, which consists of two long threads, the hardened secretion of two large glands that open on the under-lip.

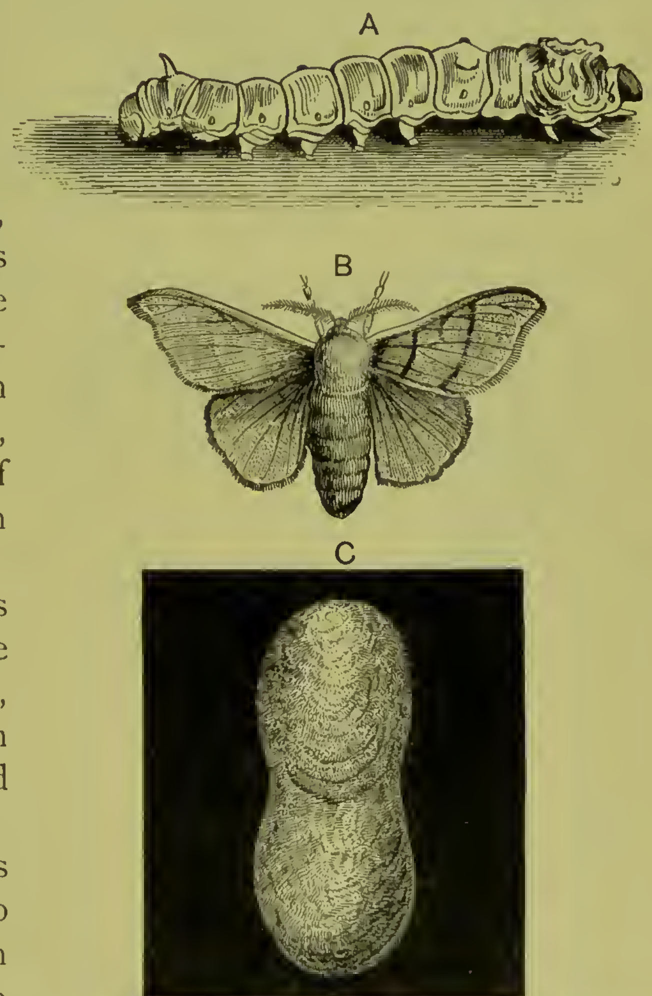


Fig. 1189.—Silk-Worm Moth (*Bombyx mori*). A, Caterpillar (silk-"worm"); B, female moth; C, cocoon.

The material known as "cat-gut" is made from the secretion of the silk-glands, which are removed from the caterpillar and subjected to suitable treatment.

The culture of silk-worms is generally supposed to have been first practised in China, the first allusion to it dating back to 2640 B.C., according to Chinese records. Thence the industry spread through Korea into Japan, and also into India, Persia, and Central Asia. Its introduction into Europe is ascribed to the Emperor Justinian, who is said to have induced a couple of Persian monks to undertake a journey to China with the view of surreptitiously obtaining eggs. These worthies are stated to have been successful in their mission, reaching Constantinople with a supply of eggs (concealed in bamboos) in the year 550 A.D. To this source the silk-industry of Southern Europe

may be traced, and to France and Italy, in particular, it is now of great importance. In the former country about 137,500 cwts. of raw silk (worth £1,080,000) is produced annually, while the Italian yield in 1902 was 823,718 cwts. (worth £12,355,057).

Of late years the Chinese have engaged in the culture of the Oak Silk-Moth (*Saturnia Pernyi*), of which the larvæ feed on oak-leaves. The silk is coarser and less valuable than the ordinary kind, but possesses the merit of greater strength. An allied species (*S. yama-mai*) is cultivated in Japan.

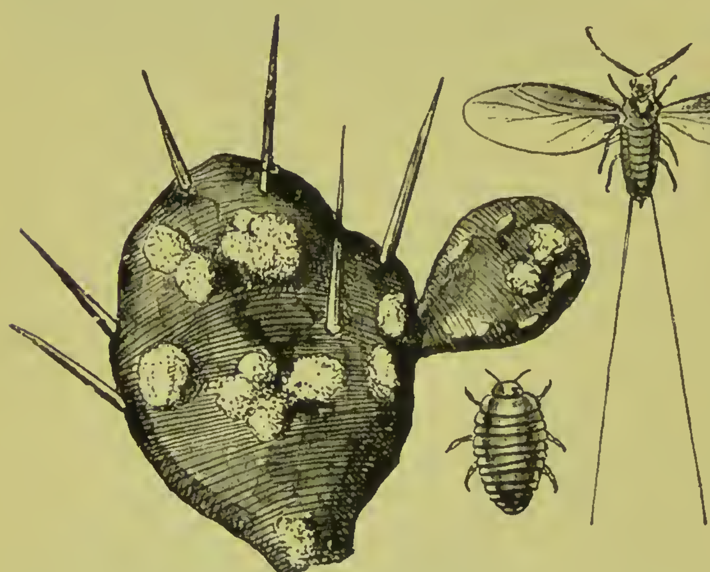


Fig. 1190.—Nopal (*Opuntia coccinellifera*) and Cochineal Insects (*Coccus cacti*), enlarged, female to left, male to right

How far silk is important to Britain may be gathered from the fact that in 1902 we imported 1,252,848 lbs. of raw silk worth £728,020, and silk goods to the value of £14,321,541.

THE COCHINEAL INSECT (COCCUS CACTI, fig. 1190).—The colouring-matter known as cochineal, as also (to some extent) the pigments known as carmine and lake, are derived from a species of bug native to Mexico, which feeds upon the Nopal (*Opuntia coccinellifera*), a plant of the cactus sort. The culture of this insect dates back to the times of the ancient Mexicans, and is now of some importance in Central America. The insect and its food-plant have also been successfully introduced into the Canary Islands, Algeria, Java, and Australia. The colouring-matter is obtained from the dried bodies of the female insects, which are ground and extracted. It requires about 70,000 of them to produce a pound of cochineal. The introduction of cheap aniline dyes has caused this industry to decline, while carmine and lake can now be manufactured chemically.

NEW EDITION, REVISED AND GREATLY AUGMENTED.

Ogilvie's Imperial Dictionary OF THE ENGLISH LANGUAGE. A complete Encyclopedic Lexicon, Literary, Etymological, Scientific, Technological, and Pronouncing. Edited by CHARLES ANNANDALE, M.A., LL.D. Illustrated by above three thousand engravings on wood, besides a splendid series of full-page plates, many of which are coloured. This edition of the IMPERIAL DICTIONARY is beautifully printed on paper of imperial size, specially made for the Work. It is issued in eight Divisional Volumes of a handy size for reference, bound in cloth, with a fine design on side, at 10*s.* net each volume.

The reception accorded by the press and the public to this new edition of the IMPERIAL DICTIONARY has been such as to show that the care and labour bestowed upon it have met with due recognition, and to prove that it will continue fully to maintain its established position as a standard lexicon of the English language, and as a work of the highest utility for the purposes of general reference and everyday requirement.

DISTINCTIVE POINTS.

To sum up the chief points of this edition—

I. It is the latest revised dictionary, and has a supplement of many thousand new words.

II. It contains more words, exclusive of compound and obsolete words, than any other English dictionary.

III. The pronunciation is explained on a plan which is simplicity itself.

IV. It gives the pronunciation and the meaning of the word as recognized *to-day.*

V. It has more illustrations than any other English dictionary.

VI. It has full-page plates (coloured and otherwise), which are an outstanding feature of the work No other English dictionary contains full-page plates.

VII. It has clear type, beautifully printed on fine paper, and is substantially and elegantly bound.

VIII. It has a specially prepared Supplement issued with *each* volume, and not, as is usually the case, relegated to the end of the complete work.

IX. It has a very full Appendix, probably the best and finest given with any dictionary in the world.

X. It is sold on a plan at once acceptable and convenient, within the reach of all, and the price is very moderate.

"The IMPERIAL DICTIONARY", says the *St. James' Gazette,* "is a work which fairly deserves the epithet of monumental. It is really what it professes to be—'a complete encyclopædic lexicon, literary, scientific, and technological'. In other words, it is the best dictionary of its kind in the English language, and its kind is the best."

"We have no hesitation in saying", writes the *Spectator,* "that it will prove a most thorough piece of workmanship, and that among reference-books of its class it will hold the first place, both as an authority and a source of instruction and entertainment."

"The encyclopedic method of treatment which has been adopted", remarks the *Athenæum,* "will be found of the greatest service, affording as it does to the reader the advantages of the ordinary dictionary combined with those of the encyclopedia."

The *St. James' Gazette* says:—"The encyclopædic part is executed with great skill and accuracy; and the genius of the editor has been exercised with the power and precision of a hydraulic press upon the enormous masses of facts with which he has had to deal".

The Cabinet of Irish Literature:

SELECTIONS FROM THE WORKS OF THE CHIEF POETS, ORATORS, AND PROSE WRITERS OF IRELAND. Edited by CHARLES A. READ, F.R.H.S., and KATHARINE TYNAN HINKSON. In 4 volumes, super-royal 8vo, cloth extra, gilt edges, price 8*s.* 6*d.* net each.

Coulson Kernahan

As there is an Irish Nationality, so there is an Irish Literature in which that Nationality has found expression. And what a magnificent Literature it is! how brilliant the roll of Irish writers from Swift, Steele, and Goldsmith, to Sheridan, Grattan, Moore, and the score of gifted men and women who are identified with the present renaissance of Irish letters!

THE CABINET OF IRISH LITERATURE is an attempt to give every Irishman, every Irish household, a share in the priceless treasures with which the literary genius of the race has enriched mankind.

It brings within the compass of a single great work a representative selection of all that is best in Irish Literature. Not, be it said, the old Irish Literature in the old Irish tongue; of that most is unknown to the people itself, though a good deal of it, in translation, will be found in this book. By Irish Literature is meant the Literature read and understood by the Irishmen of the present day—the expression of the ideas they really feel, of the life they truly live, in Mayo, in Limerick, in Cork, and in Derry.

It is a selection made without fear or favour, free from any bias, religious, political, or social. Merit is the only passport to its pages.

It gives, in brief pointed biographical notices, the life-history of every great Irish writer. We are enabled to realize the personality of the man as well as appreciate the qualities of his work.

It deals not only with the past but with the present; and it is the only work that brings home to us by illustrative extracts the great revival in Irish Literature that is now taking place. W. B. Yeats, Douglas Hyde, George Bernard Shaw, Nora Hopper, Seumas MacManus, Richard Ashe King, George Egerton, Moira O'Neill, are a few among the many scores of modern writers whose works are represented in the CABINET.

No Irishman who is proud of his nationality can afford to be without a work which thus focuses the whole intellectual activity of the race. To the younger generation it will be an inexhaustible source of inspiration, a priceless influence in forming their taste, in moulding their character—in a word, in perpetuating those qualities which now, as in the past, are associated with the name of Irishman.

The CABINET was originally planned by Mr. Charles Anderson Read, but this accomplished Irish poet and novelist did not live to see the fruition of his hopes. His work was completed by Mr. T. P. O'Connor, under whose auspices the first edition was issued. Now, after the lapse of nearly a quarter of a century, the time has come for a new edition of this monumental work, which shall take due account of the extraordinary activity in Irish letters during the intervening years. Under the able editorship of Miss Katharine Tynan (Mrs. Katharine Tynan Hinkson), herself one of Ireland's most distinguished writers, the work has been thoroughly revised and brought down to the present hour.

F. Frankfort Moore

In its get-up it is all that a book of its great importance should be. The illustrations are many and of the highest artistic value. Some of the most eminent black-and-white artists of the day, including John H. Bacon, Charles M. Sheldon, W. Rainey, R.I., G. P. Jacomb-Hood, R.I., and W. H. Margetson, have been commissioned to illustrate typical scenes from the masterpieces of our literature, and these drawings, rendered by the latest processes of photographic reproduction, and printed on specially prepared paper, add an unique charm to the work. The CABINET is further embellished with a large number of photographs of the most eminent Irish writers; and the cover design, in gold upon green cloth, is the work of Talwin Morris, the well-known designer.

The Book of the Home.

AN ENCYCLOPÆDIA OF ALL MATTERS RELATING TO THE HOUSE AND HOUSEHOLD MANAGEMENT. Produced under the general editorship of H. C. DAVIDSON, assisted by over one hundred specialists. Copiously illustrated by coloured and black-and-white plates and engravings in the text. In 4 volumes, super-royal 8vo, cloth, with artistic design, price £2, 2*s*. net. Also in 8 divisional volumes, cloth, price 5*s*. net each.

THE BOOK OF THE HOME is intended to form a complete work of reference on all subjects connected with household management. No efforts have been spared to ensure that every matter bearing upon the Home and Home Life shall receive full and sufficient treatment, and that the information given shall be reliable and in the best sense of the phrase up-to-date.

A few among over one hundred specialists who have contributed to the work:

Mrs. ADA S. BALLIN, Editor of *Baby—the Mother's Magazine*, and of *Womanhood*.

Miss BERTHA BANNER, Training Teacher of Sewing and Dressmaking at the Liverpool Technical College for Women.

Mr. A. BLACK, C.E., Architect, Author of *First Principles of Building*.

Mrs. DAVIDSON, Author of *Dainties*, *What our Daughters can do for themselves*, &c.

Miss J. FORSTER, Principal of the Cheshire County Council Dairy Institute.

Mrs. H. R. HAWEIS (the late), Author of *The Art of Decoration*, *The Art of Beauty*, &c.

Miss HELENA HEAD, Principal of the Liverpool Girls' School for Secondary Education in Domestic Science, and Author of the *Manual of Housewifery*.

Mrs. A. HODGSON, Home Decorator to *The Lady*.

Mr. R. KEITH JOHNSTON, Author of *Household Difficulties and How to overcome Them*.

Miss GERTRUDE J. KING, Secretary to the Society for Promoting the Employment of Women.

Miss E. E. MANN, Head Teacher at the Liverpool Training School of Cookery.

Colonel M. MOORE-LANE, Contributor to the *Field* and other agricultural papers.

Mrs. C. S. PEEL, Dress and Household Editor of *Hearth and Home*, and Author of *The New Home*.

Miss. B. SIBTHORPE POOLEY, Lecturer to the Liverpool Ladies' Sanitary Association.

Miss RANKIN, Head Teacher of Laundry Work at the Liverpool Technical College for Women.

Miss FLORENCE STACPOOLE, Lecturer to the National Health Society and the Councils of Technical Education, and Author of *Handbook of Housekeeping for Small Incomes*, &c.

Mr. DAVID TOLLEMACHE, late editor of *The Chef and Connoisseur*.

The contents of THE BOOK OF THE HOME may be grouped under four heads. The first deals with all matters concerning the House—from the choice of its site to the least of its internal decorations. The householder is instructed in the laws regarding landlord and tenant, and counselled in the important matters of sanitation and ventilation, heating and lighting, and the stocking and management of the garden. The housekeeper is advised as to furnishing, everything necessary for the comfort and adornment of a well-equipped house being described in detail, hints being also given regarding removals, painting and papering, artistic decoration, arrangement of linen and store cupboards, &c.

In the second the daily routine of the Household is considered—the duties of the servants, their wages, their leisure and pleasures, the management of the kitchen, laundry, and store-room. Plain and fancy cooking receive due attention, recipes being given of a large variety of dishes, and suggestions made for breakfast, lunch, afternoon-tea, dinner, and supper. A number of menus are added suitable for the different seasons. Invalid cookery also has its special section.

In the third are discussed the legal and customary duties, and the occupations and pastimes, of Master and Mistress, the former being instructed as regards insurance and the making of a will, and the smaller matters of carving, the care of the wine-cellar, and the inspection of garden and stables, while the latter is advised as to account-keeping, payments, shopping, and innumerable other matters connected with her duties as Mistress. Other subjects treated under this head are dress, home occupations, visiting and entertaining, and indoor and outdoor amusements.

In the fourth sound, systematic, and practical advice is given as to the management, in health and sickness, and the education, of children, and also on such important subjects as occupations for boys and girls, the ceremonies necessary on the coming out of a daughter, and the preparations and formalities necessary before and after a marriage.

THE BOOK OF THE HOME will thus be at once an indispensable ally to the young bride and the novice in housekeeping, and a valuable work of reference to the more experienced.

The Natural History of Animals:

The Animal Life of the World in its various Aspects and Relations. By J. R. Ainsworth Davis, M.A., of Trinity College, Cambridge, and of University College, Aberystwyth. Profusely illustrated with full-page colour and black-and-white plates, and engravings in the text, by eminent animal artists. In 8 half-volumes, cloth extra, price 7*s*. net each.

While the sum of human knowledge is gigantic now as compared with what it was a hundred years ago, in the department of Natural History the books upon which the great majority of us must depend have undergone practically no change. The general Natural History still follows the lines adopted by Goldsmith in his famous and delightful *Earth and Animated Nature.* That is to say, they are little more than classified catalogues of animals, taking up in succession the various groups and individuals, and describing them one after another, each as standing by itself. This is not what the intelligent reader of the present day requires. He must be put in a position to take a comprehensive grasp of the subject; he demands a competent guide, not a directory, however accurate.

It is with this end in view that The Natural History of Animals has been compiled. It treats this great subject on essentially modern lines, giving an accurate and vivid account of the habits, relationships, mutual interdependence, adaptation to environment, &c., of the living animals of the world.

It is needless to say that the production of such a work demanded a man who has devoted his life to the study of biology and zoology, and who at the same time is a gifted writer and expounder. This rare combination has been found in the person of Prof. J. R. Ainsworth Davis, M.A., of Trinity College, Cambridge, and of University College, Aberystwyth, the author of the present work. Prof. Davis is well known to naturalists as an ardent worker in Natural History, particularly in the field of marine zoology. He is a very distinguished graduate of Trinity College, Cambridge, the chief scientific school in Britain, perhaps in the world, and has done a great deal of literary work, both scientific and in other directions.

Briefly, **the object of Prof. Davis's work** is to give in a readable form and in non-technical language a general survey of the whole animal world from the stand-point of modern science—and the work may fairly claim to be a **Natural History on a new plan**, the first comprehensive work in English of its own special kind. Formerly Natural History had much the character of a miscellaneous aggregate of disconnected facts, but hardly any fact or feature connected with any animal can now be considered as isolated from others; and animals as a whole must be looked upon as interrelated in the most surprising manner both with one another and with their surroundings.

Every household library should contain a Bible, a Dictionary, an Encyclopedia, and a work on Natural History. This is the "irreducible minimum"; other books we may have, these we must. For The Natural History of Animals it may fairly be claimed that it has a better title than any other work to become the **Natural History for the Household**. It is a work in which the adult reader will find a never-failing mine of information, while the younger members of the family will delight in its wealth of illustration, and its store of interesting and suggestive anecdote.

To teachers The Natural History of Animals may be regarded as indispensable. More than usual attention has of late been directed to the important subject of **Nature-study**; and in this respect the appearance of Prof. Davis's work could scarcely have been more fitly timed. In the domain of Natural History it is pre-eminently the book for the purpose. Its clear and orderly arrangement of facts, its masterly grasp of general principles, its comprehensiveness of scope and simplicity of style, combined with the most absolute scientific accuracy, render this work an invaluable book of reference for those who aspire to teach Nature-study on up-to-date principles.

The Illustrations, as befits a work of such importance, are on the most lavish scale. A large number are in colour, reproductions, by the latest processes of colour engraving, of exquisite pictures by the most eminent animal draughtsmen. In illustrating the work talent has been sought wherever it was to be found; and the list of artists is representative of several nationalities. A large number of the designs are the work of Mr. A. Fairfax Muckley, who is probably unsurpassed in the capacity to depict living creatures with absolute fidelity to detail without sacrificing the general artistic effect. Friedrich Specht, one of the most eminent German animal painters of the past century, is represented in The Natural History of Animals by many of his best designs in colour and black-and-white. W. Kuhnert, another German artist whose work is universally admired; and M. A. Koekkoek, the talented Dutch painter, are also among those who have assisted in the embellishment of the work. An important feature is the series of diagrammatic designs showing the structure of certain typical animals, specially drawn under the direction of Prof. Davis.

The Modern Carpenter, Joiner, and Cabinet-Maker: A Complete Guide to Current Practice. Prepared under the editorship of G. LISTER SUTCLIFFE, Architect, Associate of the Royal Institute of British Architects, Member of the Sanitary Institute, editor and joint-author of "Modern House-Construction", author of "Concrete: Its Nature and Uses", &c. With contributions from many specialists. Illustrated by a series of about 100 separately-printed plates and 1000 figures in the text. In 8 divisional volumes, super-royal quarto, handsomely bound in cloth, with cover design by Mr. TALWIN MORRIS, price 7*s.* 6*d.* net each. In complete sets only.

In preparing THE MODERN CARPENTER the editor has had the great advantage of working upon the basis of Newlands's *Carpenter and Joiner's Assistant*, which for nearly half a century has been accepted as a **standard authority** on the subjects of which it treats, and for many years has been recommended by the Royal Institute of British Architects as **a text-book** for the examination of that society. And yet in the present work it has been possible to preserve only a very small part of Newlands's treatise, invaluable though this has been to two generations of craftsmen. While the fundamental features of arrangement and method which distinguish this famous work have been retained, the matter has had to be **entirely rewritten**, and many new sections have been added, on subjects not touched upon in the older work, with which the carpenter of the present day requires to be familiar.

In the new book, indeed, the old foundations that have stood the test of half a century of practical use have been retained, but **the superstructure is wholly new.**

The lesson to be learned from this fact is not far to seek. It is that the modern carpenter requires a **far wider expert knowledge** than sufficed his predecessor. The development of wood-working machinery, the introduction of new kinds of timber, improvements in the design of structures, the more thorough testing of timbers, and progress in the various industries with which Carpentry, Joinery, and Cabinet-making are intimately allied, have all helped to render the craft more complex. The carpenter of the present day has no use for the old "rule of thumb" methods; his calling is both an art and a science, and **knowledge, knowledge, and again knowledge** is the primary condition of success.

The editor of THE MODERN CARPENTER, **Mr. G. Lister Sutcliffe,** Associate of the Royal Institute of Architects, **needs no introduction** to practical men; his name is already well known not only through his professional position in the architectural world, but through his editorship of *Modern House-Construction*, a work which, although issued only a few years ago, has already become a standard book of reference. Mr. SUTCLIFFE'S large experience has enabled him to enlist the services of a **highly-qualified staff of experts,** whose special knowledge, acquired through long years of practical work, is now placed at the disposal of every member of the craft. The first condition in selecting the contributors to the work was that they should be **practical men,** not only possessing the indispensable knowledge, but having the ability to impart it. The result is that within the eight divisional-volumes of this work we have a treatise on every branch of the craft, distinguished by four outstanding qualities:— It is (1) **complete,** (2) **clear,** (3) **practical,** and (4) **up-to-date.**

An idea of the scope of THE MODERN CARPENTER may be gathered from the fact that while its predecessor, *The Carpenter and Joiner's Assistant*, comprised only **eight** sections, the new work includes no fewer than **sixteen.** A glance at these will show that the work **covers the whole field;** it is a complete encyclopædia upon every subject that bears upon the everyday work of the practical man.

I. Styles of Architecture.
II. Woods: Their Characteristics and Uses.
III. Wood-working Tools and Machinery.
IV. Drawing and Drawing Instruments.
V. Practical Geometry.
VI. Strength of Timber and Timber Framing.
VII. Carpentry.
VIII. Joinery and Ironmongery.
IX. Staircases and Handrailing.
X. Air-tight Case-Making.
XI. Cabinet-Making.
XII. Wood-Carving.
XIII. Shop Management.
XIV. Estimating.
XV. Building Law.
XVI. Index, Glossary, &c.

The Illustrations are not the least of the many notable features of this great undertaking. The work is embellished in the first place with about **100 full-page plates,** reproduced, some in colours, by the most approved processes of mechanical engraving, and printed on specially-prepared paper. In addition to this unique collection there are no fewer than **1000 diagrams and designs** in the body of the work. No trouble or expense has indeed been spared to procure illustrations where these could elucidate the text.

Charles Dickens' Novels.

The Imperial Edition of the Novels of CHARLES DICKENS, in 16 volumes, large square 8vo, cloth extra, gilt top, price 4*s*. 6*d*. net each volume.

An Ideal Issue. ONE NOVEL, ONE VOLUME. Despite varying lengths, the paper, &c., is so adjusted that each volume is uniform in thickness and size.

The Cheapest Edition. The price of each volume is 4*s*. 6*d*. net, making the edition the *cheapest of the best editions.*

Sumptuously Bound. The cloth is of the finest and is imperial red in colour. The embellishments (produced in gold) are an appropriate design of national arms and imperial emblems by the eminent designer, Talwin Morris.

Illustrations a Unique Feature. Every picture drawn specially at enormous cost for this "Imperial" edition by the best known and most celebrated Artists of *to-day.*

George Gissing's Masterly Study. A literary character study, the work of this great authority, forms one of the volumes of this issue, and is illustrated with pictures of some of the quaint old hostelries and places made famous by Dickens, and is altogether an invaluable addition to this issue.

Presentation Portrait. To every subscriber to this edition will be presented with the last volume a magnificent Photogravure of Charles Dickens. It is printed on the finest plate paper, 22 inches by 30 inches, and has been specially engraved for this edition.

A List of the Novels.

The following is a list of the volumes in the Imperial Edition:—

The Pickwick Papers.
Oliver Twist.
Nicholas Nickleby.
Martin Chuzzlewit.
The Old Curiosity Shop
Barnaby Rudge.
David Copperfield.
Bleak House.
Sketches by Boz.
Hard Times and Master Humphrey's Clock.
Christmas Books.
Dombey and Son.
Little Dorrit.
A Tale of Two Cities.
Great Expectations.
Charles Dickens: A Critical Study. By GEORGE GISSING.